UNIVERSITY OF CALIFORNIA
COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BERKELEY, CALIFORNIA

CIRCULAR No. 284
APRIL, 1925

THE ALMOND IN CALIFORNIA*

BY R. H. TAYLOR AND G. L. PHILP

INTRODUCTION

The almond (*Prunus communis*) is supposed to be native to the countries around the Mediterranean. It is related to the peach which it resembles in manner of growth and character of blossoms and leaves. The wood, however, is much harder and the tree lives longer under equally favorable conditions. The fruit has a thin, leathery pericarp or hull, which corresponds to the thick, fleshy portion of the peach, and which splits upon ripening and generally opens when dry, exposing the nut inside.

ALMOND PRODUCTION AND DISTRICTS

The production of almonds in the United States is confined almost entirely to California, where over 99 per cent of the crop is raised. With the 1915 crop the production entered upon what appears to be a long prospective increase. The large acreage of almonds set out in the past few years is the result of greatly improved market conditions which are due to the successful work of the California Almond Growers' Exchange. According to recent figures,[1] there are now approximately 100,000 acres of bearing and non-bearing trees and large acreages are still being planted.

Table 1 gives, by counties, the comparison of the number of acres in bearing in 1909, with the bearing and non-bearing acreages for 1923.

* This circular is a revision, by the junior author, of California Agr. Exp. Sta. Bull. 297, by R. H. Taylor.

1 California Crop Report, Calif. State Dept. Agr., Special Publication 43, p. 21, 1924.

TABLE 1

COMPARISON OF BEARING ACRES OF ALMONDS IN THE VARIOUS COUNTIES IN 1909[2] WITH THE BEARING AND NON-BEARING ACRES IN 1923

County	Bearing acres, 1909	Bearing acres, 1923	Non-bearing acres, 1923
Alameda	246	400	.....
Amador	.....	14	7
Butte	1051	5133	572
Calaveras	.....	23	7
Colusa	201	3200	5900
Contra Costa	2613	2500	522
Fresno	.....	84	167
Glenn	359	2703	217
Kern	.....	170	80
Kings	.....	15	5
Lake	103	300	346
Los Angeles	962	1062	166
Madera	.....	141	108
Marin	.....	10	7
Mendocino	.....	11	.....
Merced	214	3321	599
Monterey	.....	2400	150
Napa	234	20	23
Placer	144	389	20
Riverside	272	1432	53
Sacramento	829	2376	551
San Benito	87	130	26
San Bernardino	.....	8	7
San Diego	.....	331	185
San Joaquin	1212	5592	481
San Luis Obispo	116	8489	21,987
San Mateo	.....	6	4
Santa Barbara	.....	2	1
Santa Clara	323	200	160
Shasta	.....	60	.....
Siskiyou	.....	3	3
Solano	1228	1776	126
Sonoma	.....	25	15
Stanislaus	421	4170	1080
Sutter	769	2090	32
Tehama	411	662	24
Tulare	.....	832	46
Ventura	.....	731	57
Yolo	1862	5554	2000
Yuba	39	290	60
All other counties	827	.....	.....
The State	14,541	56,646	35,794*

* Estimated acreage planted in state, 1923, 5,921 not included.

[2] Figures for 1909 from Calif. State Board of Hort., Mo. Bull., vol. 8, no. 4, p. 144, 1919.

It is interesting to note that the bearing acreage is confined mainly to the upper part of the great interior valley, extending from Tehama County on the north to Merced County on the south. The largest proportion of the non-bearing acreage is confined to San Luis Obispo County, where the almond is being extensively planted. Figure 1 shows the location of the almond plantings.

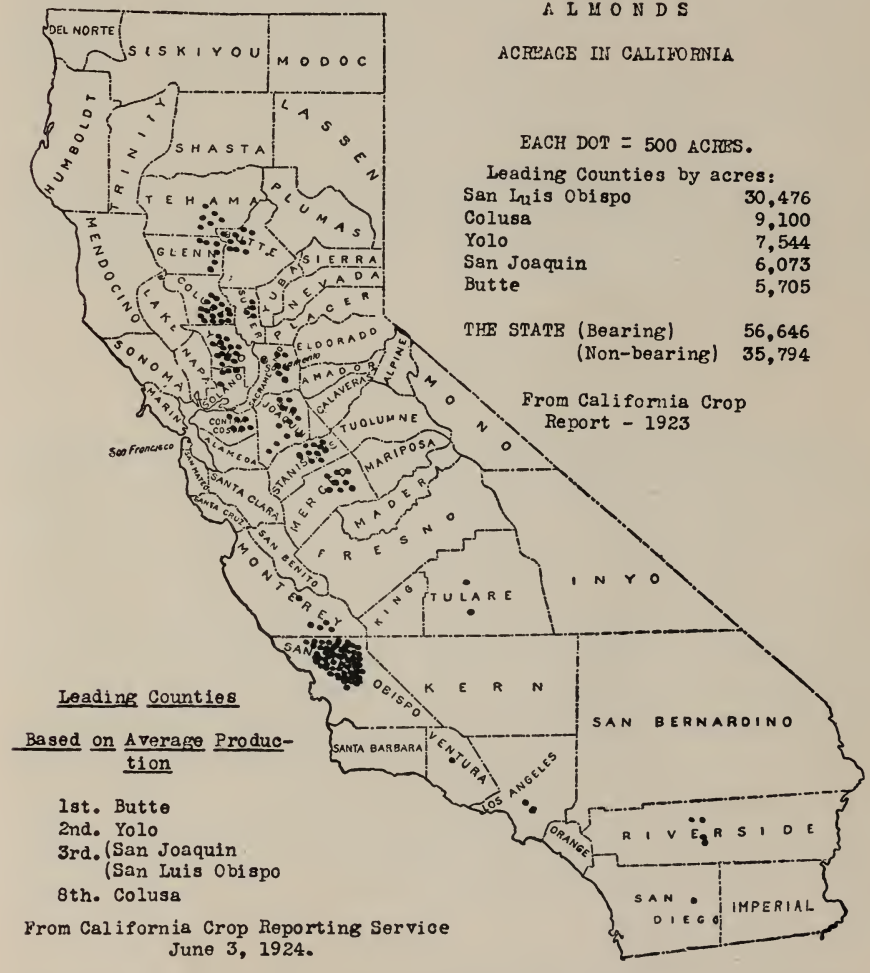

Fig. 1.—Outline map of California showing the almond acreage by counties. Each dot represents 500 acres. The leading counties based on average production are also listed.

While California produces practically all the almonds grown in the United States, there are millions of pounds imported into this country every year. Table 2 gives the quantities of almonds brought into the United States during the years 1917 to 1923, inclusive:

TABLE 2

ALMOND IMPORTS. CROPS OF 1917 TO 1923[3]

Imports for	Crops of	Pounds Unshelled	Pounds Shelled	Total pounds
1917–18	1917	4,278,990	19,561,155	23,840,145
1918–19	1918	6,733,512	23,594,915	30,328,427
1919–20	1919	7,355,894	26,326,245	33,682,139
1920–21	1920	6,622,340	13,816,044	20,438,384
1921–22	1921	4,637,002	26,705,621	31,342,623
1922–23	1922	4,719,348	22,973,337	27,692,685

Since the cost of producing almonds in Europe and of transporting them to the Atlantic seaboard is low, the Californian grower must become thoroughly familiar with the most economical methods of production and marketing.

HABITS

The almond is the first of the deciduous fruit trees to start growth and come into bloom in the spring, and is normally the last one to shed its leaves in the fall. In other words, it has a very short period of rest. When the trees are forced into premature dormancy by mites or lack of moisture, they reach the end of their normal rest period before the winter season is over. Then the first warm weather in spring will bring the trees into bloom. In some cases where moisture and temperature conditions are favorable late in the fall, they may actually blossom before the winter season begins. In young trees that have become dormant unusually early, the rest period may terminate and the tips of the branches resume growth and continue slowly to develop new leaves at the terminals throughout the winter. Trees which have been kept growing until the leaves have been forced to fall by the cold weather and frosts of winter, do not usually blossom so early in the spring.

Young trees blossom somewhat later than older ones, and buds on sucker growth blossom later than those on the more mature portions of the same tree. The difference may amount to three or four days or almost a week. Well grown trees carry large numbers of blossoms over the entire tree.

[3] Figures from the California Almond Growers' Exchange.

The wood of the almond is very hard and strong, enabling the tree to bear the weight of heavy crops where proper pruning has been given during the first years of growth. As with other fruit trees, the almond is subject to heart-rot and needs care to prevent the checking and cracking of large wounds and consequent infection with decay organisms. The hardness of the wood makes it excellent fuel, and when old orchards are being dug up, the returns from the sale of wood often more than pay for the expense of digging and cutting up the trees and burning the brush.

The nuts are of two general classes—sweet and bitter. The former is primarily the almond of commerce, though the latter is used largely in the manufacture of almond oil and almond flavoring, as well as in the manufacture of prussic acid. The bitter almond is also much used in nurseries as a rootstock upon which to bud the almond and some other fruits.

FACTORS LIMITING PRODUCTION

While the almond is in many ways an easy tree to grow it is rather particular in certain pollination, climatic, and soil requirements.

POLLINATION

Tufts and Philp[4] found that all of the varieties of almonds they tested are self-sterile. This list includes the Big White Flat, California, Drake, Eureka, Golden State, Harriott, I. X. L., Jordan, King, Klondike, Languedoc, Lewelling, Ne Plus Ultra, Nonpareil, Peerless, Princess, Reams, Sellers, Silver Shell, and Texas.

In addition certain almond varieties are inter-sterile. For example, the I. X. L. and the Nonpareil proved practically inter-sterile. The Languedoc and the Texas are inter-sterile as shown by two seasons' work.

In order to insure cross-pollination it is necessary therefore to interplant varieties which not only are inter-fertile but blossom at about the same time. The accompanying chart (fig. 2) gives the average blooming periods of certain almond varieties. The date of bloom is of course dependent upon many factors, such as soil, season, and location.

[4] Tufts, W. P., and Philp, G. L., California Agr. Exp. Sta., Bull. 346, 1922.

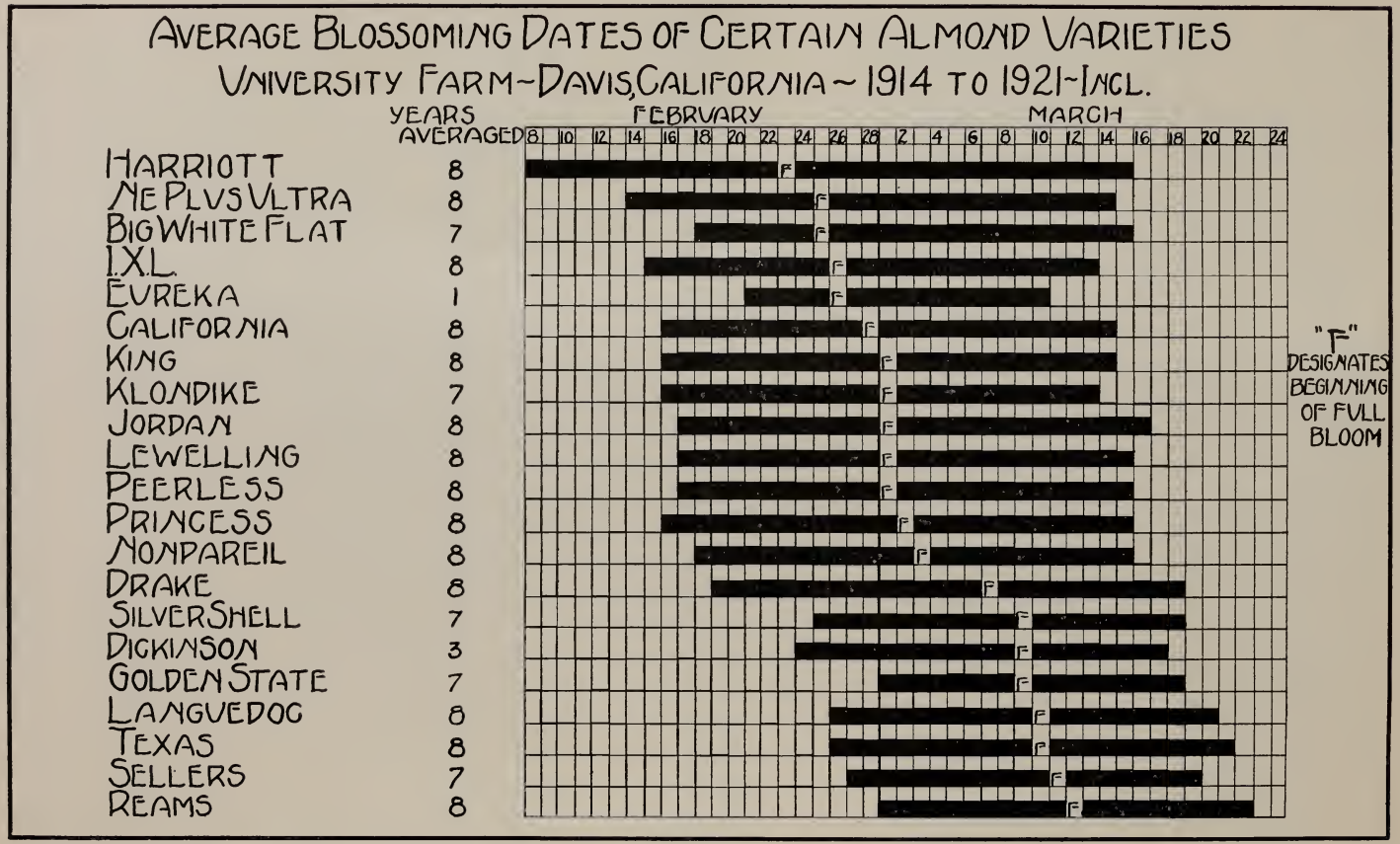

Fig. 2.—The average dates of the first, last, and full bloom of certain almond varieties covering a period, in nearly all instances, of eight years. The number of years averaged is shown in a separate column for each variety. From Bull. 346, Calif. Exp. Sta.

Figure 3 gives the period of effective bloom of certain almond varieties for the year 1917 growing under the same conditions.

Satisfactory pollinizers for various varieties are listed below:

1. For *California*—Nonpareil and Drake.
2. For *Drake*—California, Ne Plus Ultra, Nonpareil, and Texas.
3. For *Eureka*—Nonpareil.
4. For *Harriott*—Ne Plus Ultra.
5. For *I. X. L.*—Ne Plus Ultra.
6. For *Languedoc*—Drake.

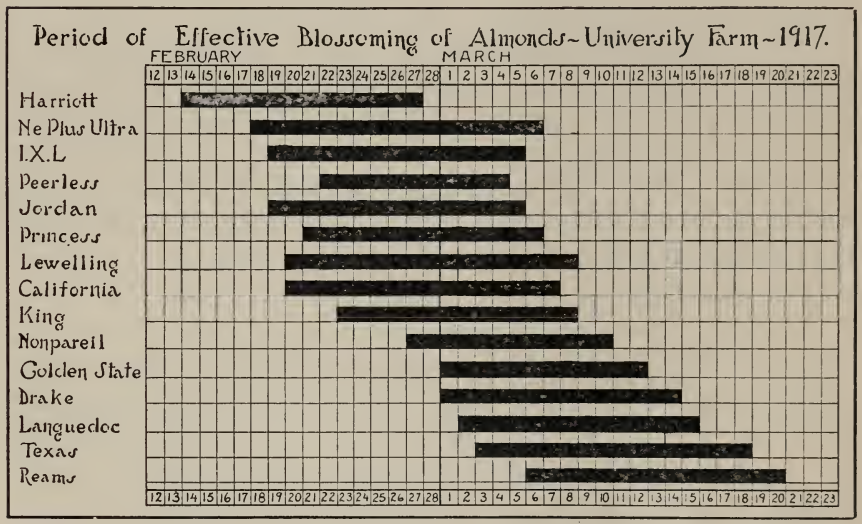

Fig. 3.—The effective blooming period of certain almond varieties during the season of 1917. The dates in this table cover the time each variety was in conspicuous bloom and therefore of maximum attraction to insects. From Bull. 346, Calif. Exp. Sta.

7. For *Ne Plus Ultra*—California, I. X. L., Jordan, and Nonpareil.

8. For *Nonpareil*—California, Drake, Jordan, Ne Plus Ultra, Peerless, and Texas.

9. For *Reams*—Texas.

10. For *Texas*—Drake and Nonpareil.

There are a few other suggestions concerning pollination of almonds which are listed below:

(*a*) Pollinizing agencies, such as the honey bee, are necessary to set a good crop of nuts.

(*b*) One colony of honey bees to each acre of orchard insures a proper transmission of pollen.

(*c*) To facilitate cross-pollination and convenience in harvesting, it is best to plant two, three, or four rows of one kind and then a similar number of the other variety. When a smaller number of the pollinizer is desired, two rows to every four rows of the standard variety can be planted.

(*d*) When it is desired to reduce the number of pollinizing trees to the minimum, one tree in twenty-five is perhaps sufficient, although at least one tree in eight is strongly recommended. This can be done by planting the pollinizing variety as every third tree in every third row. Such an arrangement, however, makes it difficult to avoid mixing varieties in harvesting.

(*e*) Planting several varieties also assists greatly in lengthening the harvest season and thus enabling an individual to handle larger crops with fewer men and less equipment. For example, the four best varieties, the Nonpareil, I. X. L., Ne Plus Ultra, and Drake, ripen in the order named: the Nonpareil ripening about two weeks before the I. X. L., the Ne Plus Ultra about a week after the I. X. L., and the Drake about two weeks after the Ne Plus Ultra.

CLIMATE

Heat.—Where the conditions of soil and moisture are favorable, the almond will endure the intense heat of the interior valleys and even of the Imperial Valley, provided it is pruned properly to shade the main branches and prevent sunburn. If trees are opened up suddenly to the intense heat of the summer sun, they are apt to sunburn, but if this opening up is done gradually, the bark will become inured to the new conditions without danger. The nuts grow and ripen more satisfactorily in the greater heat of the interior than along the coast.

Frost.—The almond tree is hardy and can endure without injury fully as much cold as the hardiest peach. Trees are found growing well in Illinois, Nebraska, Ohio, New York, and other Eastern states. In very favorable seasons they may even bear fruit, though this happens very seldom, because of their habit of blooming before the spring frosts are over. The first warm weather seems to start the trees into bloom, especially where the enforced dormant season of winter is very long.

While the wood is relatively hardy, the blossoms on the other hand, are very tender. There is a great range in the degree of frost which causes injury, depending largely upon the condition of the tree during the time that the fruit-buds are forming and developing, as

well as upon the duration and severity of the frost. Buds and blossoms on trees which have been forced into premature dormancy, either by lack of moisture or by severe attacks of red spider, are much more susceptible to frost injury than those on trees which have continued growth late enough in the fall to provide for the proper development and maturity of the buds. After differentiation of fruit-buds commences in the summer, the almond leaves should remain on the tree until late into the fall in order to strengthen and develop the fruit-buds and store up elaborated food material for their normal development through the winter. Studies of almond buds gathered from healthy trees which held their leaves until late fall frosts at Davis, showed the first evidence of differentiation of fruit or flower-buds about mid-August, while the flower was not completely developed until early February of the next year, following. During the intervening time, development proceeded unchecked through the winter even though the tree was apparently dormant. During the time the crop is ripening on the trees, little is done toward storing food material for the buds. If the leaves turn yellow or drop soon after harvest, the trees do not have the opportunity of storing a sufficient supply of plant food for their normal requirements and the buds are insufficiently nourished during the winter period. The resulting buds are weakened, and the indications are that they are unable to endure unfavorable climatic conditions in the spring, such as light frosts, continued cold weather, or sudden changes from warm to cold.

The most tender stage in the blossoming and development of the young fruit seems to be immediately after the dropping of the calyx lobes and when rapid growth begins. The blossom becomes more and more tender as it opens. Blossoms with the petals exposed but not yet opened have been known to stand a temperature of 24° F., and blossoms with petals beginning to fall have stood 28° F. No records are available as to the duration of these temperatures. In other cases, blossoms with the petals falling have been killed by temperatures of 30° and 31° F. It must be remembered in this connection that the almond blooms earlier than other orchard fruits and, therefore, is often subjected to much more severe frosts than occur during the blooming period of the later fruits. The greatest injury is likely to occur when the frost follows one or more days of warm weather. When the mean temperature both day and night remains low, frosts that might otherwise kill the flowers or setting fruit do no harm. This is what occurred in February, 1917, at the University Farm, when repeated frosts at blooming time did no harm whatever.

Freedom from frost and adequate air drainage are closely related. The lands along the lower foothills immediately above the floor of the valleys and the lands along the built up banks of rivers are less subject to frost because the cold air flows from them to the lower lands adjacent. For this reason, the planting of almonds in the lower lands of the valleys, no matter how large the valleys may be, should be avoided. An exception may be the locality which has been thoroughly tested as to frost occurrence for a long period of years and has proved to be frost free, because of some peculiar situation with favoring air currents or air drainage, such as might exist near a natural draw in the hills where the settling of the cold air in some portions of the adjacent valley might be prevented. Such locations are generally confined to very small areas. Sometimes an opening or draw in the hills may serve as an outlet for the drainage of much colder air from considerably higher elevations beyond, and then the danger from frost is very greatly increased. This is very common where cañons act as drains to conduct the cold air from the high Sierras to the valleys below.

Variable weather conditions, especially as regards temperature in the spring after growth commences, are undesirable. At this time sudden changes of weather, even without frost, often destroy the crop. However, it is probable that most of the dropping of fruit when the size of peas or larger, is due to improper pollination.

Humidity.—Foggy or moist weather during ripening or harvesting promotes the growth of molds and consequent darkening of the shells, which then require much heavier bleaching. It also prevents the rapid and thorough drying-out of the kernel, which when moist absorbs sulfur fumes and sometimes become rancid in less than six months.

Much damp weather in spring encourages the growth of "shot-hole" fungus in the blossoms and fruit, often causing the loss of a considerable portion of the crop. The loss of leaf surface from this fungus is also sometimes so great as materially to affect the vigor and vitality of the tree.

Rainfall.—The average amount of rainfall which will maintain the trees and enable them to bear regular crops depends on its annual variations, its distribution throughout the year, the time and intensity of the rains, the character of the weather following, and the ability of the soil to receive and retain them. Ordinarily, however, with the above factors favorable, it is conceded that where the winter rainfall averages sixteen inches, almonds can generally be grown, although

not always very satisfactorily, without irrigation, if the orchardist exercises reasonable care in conserving the moisture for the use of the trees. Where the rainfall is inadequate, some means of irrigation must be found to make up the deficit.

In some sections the annual rainfall varies greatly from year to year. Often it falls in such a way that a large proportion of it is lost in the surface run-off. In many places the soil is so leachy that it is incapable of holding sufficient water for the use of the trees throughout the summer, much of the winter rainfall being lost in the underground drainage. Under any of these conditions, forty inches of rainfall might not be sufficient.

Continued rainy, damp, and cold weather at blooming time is apt to destroy the pollen and thus prevent the fertilization without which a crop is impossible. Such weather also prevents insects from working, particularly bees, which are the principal means of pollinating almonds.

Soil.—The almond is a deep-rooting tree which draws heavily upon the plant-nourishing elements of the soil. In ripening the large number of fruits which it is required to do, the tree must draw upon a considerable area of soil in order to supply the large amount of mineral matter that is needed to develop and mature the seeds. Analyses of almonds made by Colby[5] show, when compared with other commonly grown fruits and nuts, that the almond tree leads in the total quantity of mineral matters withdrawn from the soil. Colby states that "The stone fruits fall much below the almond in total ash (mineral matter) excepting the olive, the ash of which, however, is largely silica (nearly eight-tenths), an ingredient so plentifully distributed in all soils that it is of no pecuniary value."

Hardpan.—Compacted substrata in the soil, whether they be hard clay layers or cemented layers of silicous, ferruginous or calcareous origin, are objectionable. Not only do they keep the roots from foraging to a considerable depth as they normally tend to do, but they prevent proper drainage and aeration of the soil. If such layers are comparatively thin, that is, not more than one or two feet thick at the most, they may be shattered with dynamite so as to allow the moisture, air, and roots to penetrate to better soil below. Hardpan, therefore, should be avoided when it is too thick to be broken up or where it is not underlaid by desirable soil.

Humus.—A plentiful supply of humus in the soil is essential. It not only improves the physical condition of the soil, but assists drainage and moisture retention and renders the plant food available for

[5] Colby, Geo. E., California Agr. Exp. Sta., Ann. Rept., pp. 142–159, 1898.

the use of the trees and for the maturing of full crops. Many orchards are very light producers because of a deficiency of humus in the soil.

Drainage.—The almond root is very particular as to its air and moisture requirements in the soil. It suffers from standing water in the soil especially during the growing season. Exclusion of air by excessive moisture is believed to be one of the most productive causes of "sour-sap." If allowed to continue for any considerable length of time, such a condition will cause the death of many or even of all the roots and, with them, the top.

Water Table.—A factor which is very commonly overlooked in connection with the natural drainage of almond lands is the position of the water table at different seasons of the year. Great care must be exercised to choose a location where the water table does not rise during the summer. This is a very serious problem in many irrigation sections. Where the water table during the winter months is less than twelve feet in depth, it is desirable to have as little fluctuation as possible. Where fluctuations take place at a greater depth than twelve feet, they are not generally serious. The ideal condition is one where the water table is highest in the winter and quickly drops, after the winter rains are over, to a depth of from ten to twelve or fifteen feet, remaining at that point during the remainder of the growing season.

The soil in addition to being well drained, must be sufficiently retentive of moisture to supply the tree throughout a long, dry growing season. If the soil will not retain a sufficient amount of the winter and spring rains, recourse must be had to irrigation to supply the deficiency.

Alkali.—Alkali lands are unsuited to almond culture and should be carefully avoided.

To summarize the soil requirements for almond culture: the ideal almond soil is a deep medium loam, uniform in texture, or nearly so, well drained, and yet retentive of moisture for the use of the tree during the summer. Fortunately, some of the best almond soils are situated along river banks where the land is relatively high, and is, therefore, less subject to frost.

The various requirements of growth and production are those mentioned above. Often these conditions may be approached in a relatively shallow soil. It is essential to understand that trees, while growing and bearing on shallow soils in some localities, do so because of other exceptionally favorable conditions; either the soil is unusually

well drained and yet sufficiently retentive of moisture, or the humus in the soil is plentiful and the roots are able to work into the partially decomposed rock underlying it for moisture and for some plant food. In such localities the trees may bear comparatively well because of exceptional freedom from frost in the spring. They are generally smaller, however, than those on the deeper, richer soils, and where other conditions are equal, they bear crops in proportion to their size.

PROPAGATION

Orchard almond trees are never grown from seed, which do not reproduce the type, but they are propagated by budding desirable varieties on seedling roots in the manner commonly employed in nursery practice for the peach and other stone fruits. The grower should consider carefully what rootstocks to select.

Rootstocks.—There is still much to learn regarding the behavior of the different roots under varying conditions when used as stock for the almond, but sufficient information has already been gathered to warrant certain recommendations. A survey of the California nurseries in 1922 showed that 72 per cent of the almonds were propagated on almond root and 28 per cent on peach root.

Almond Root.—Most almonds in this state are on almond roots. Where favorable soil, moisture, and drainage conditions exist the almond root is best. It will live in comparatively dry soils, but will not make a tree of large size or bear good crops if the conditions are too dry.

Where irrigation is not available, and the soil is deep and of proper texture, sufficient moisture may be retained in most years to enable the tree to grow and bear fruit. When extra dry years come, though the almond root may not enable the tree to grow or produce better than would another kind of root, it will carry the tree over a few dry seasons as well as or better than any other. Then, when sufficient moisture does come, the almond root is ready to start the tree off on its normal course with the least loss of time.

The bitter almond is often recommended as being superior to the sweet almond as a stock. This has never been proved. Experiments indicate that there is as much variation among the bitter almond seedlings grown from seed from different trees as there is among seedlings from sweet almonds. Both are equally subject to attack by gophers. There is no reason therefore for preferring one to the other provided healthy, vigorous trees are obtained.

Peach Root.—Where the soil moisture varies much in different parts of the orchard, or from time to time during the growing season, the peach root is sometimes the most satisfactory. Soils less than six feet deep, or with gravelly or hardpan layers at lesser depths, are often unsatisfactory for the almond root, and under these conditions the peach root may be better. The peach root is a little better where irrigation is practiced during the summer, and especially where there is danger of an excess of water remaining too long in the soil. The peach does not thrive with standing water around its roots, but will better withstand fluctuating or temporary extremes in water supply than the almond. Its union with the almond is entirely satisfactory.

Davidiana Root.—Within the past seven or eight years the United States Department of Agriculture has introduced the seed of a Chinese peach, *Prunus davidiana,* the root of which is more resistant to alkali than that of the ordinary peach. This has been found to unite readily with the almond, although experiments have not yet gone far enough fully to determine its true value. It gives promise, however, of being a desirable stock for sections where alkali may be troublesome.

Unsuitable Roots.—The Myrobalan plum has frequently been recommended as a stock for the almond on poorly drained soils. The two make a strong union, but the plum root grows much more slowly than the almond top, showing that the trees on Myrobalan root are pinched-in below the union. Even young trees show the same effect. Almond trees on Myrobalan root do not make such large trees nor do they bear such satisfactory crops in any portion of the state where it has been possible to compare them with the same varieties on other roots in similar situations.

The apricot is occasionally recommended because of its strong, thrifty growth, but the union is not satisfactory. The trees grow well for awhile, but before they reach full bearing, they generally break off at the union through the leverage of the swaying top in even moderate winds.

Top-working Old Trees.—Where the varieties in an old orchard are unsuitable it is often advisable to work over old trees to more desirable varieties. This may be done by grafting or budding. The general practice is to cleft-graft the large branches at a convenient height from the ground with two or more scions, according to the size of the limb. On branches where the scions fail to grow, it is advisable to save several of the suckers and bud into these. Generally it is advisable to leave a branch as a "sap puller," which may be removed the year after the grafting. In windy sections where there is con-

siderable danger of the scions being blown out, it is advisable to graft about half of the tree, one season, leaving the other half of the top to serve as a windbreak until the top-worked portion has a chance to unite solidly. The other half of the tree may then be top-worked the following year.

It is sometimes desirable to top-work the orchard with some other fruit. Most stone fruits, particularly prunes, plums, and peaches, unite readily with the almond. The apricot, however, cannot be successfully top-worked on it.

CULTURE

Planting.—Before planting almonds the land should receive the same careful preparation needed by other fruits. Special care must be taken to insure thorough aeration of the subsoil by breaking up all hardpan, plow-pan, or other compacted layers in the soil, where possible.

Distance.—Almonds in most soils should be planted about thirty feet apart. In rich, deep soils the trees quickly fill the intervening space, the roots occupying the entire soil area long before the tops touch. In poor, shallow soils, or soils deficient in available moisture, the trees may not occupy the entire area above ground, but their roots will require more lateral feeding space to enable the trees to attain the size and bear the crops they should.

Trees planted too close together often exhaust the moisture of the soil before the growing season is over. This shortage of moisture, and mites—commonly called red spider—cause loss of the leaves long before the normal period for falling. Under such conditions the fruit-buds are unable to make the vigorous growth they should, and are unable to endure without serious injury the degree of frost or the other unfavorable conditions that stronger buds withstand.

The trees must have plenty of sunlight. If planted too close together, they grow too high, each striving for the light which is available only from above. In figure 4 the upward tendency of the trees is clearly shown. Such trees, if properly pruned, have a much greater tendency to send out numerous water-sprouts than trees which have plenty of room for the tops to expand laterally. After the tops of the trees interlock and shut out the sunlight from the lower portions, the smaller branches and fruit spurs in these parts gradually weaken and die, and eventually the entire crop is produced on or near the tops of the trees, where alone direct sunlight is available. The excessive upward growth of the trees, with the consequent forcing of the

fruit bearing to the top, not only greatly increases the difficulty and cost of pruning, spraying, and harvesting, but reduces the possible bearing surface of the trees.

Setting the Trees.—To secure a uniform and vigorous stand, the utmost care is necessary in setting out the trees. The holes should be dug just deep enough and wide enough to accommodate the roots without crowding, after they have been properly trimmed. The actual size of hole will be determined by the size of the average root

Fig. 4.—Almonds planted twelve feet apart. Trees in very weak condition and almost entirely defoliated by mites before harvest. The few nuts ripening on the trees are small "sticktights." Photograph taken September 21, 1915.

system. As a rule, for the medium sized, one-year-old tree, a hole about fourteen inches wide and about the same depth is sufficient. If the ground has been properly prepared, large holes, except in cases of replants, are of no advantage. In fact, they are a disadvantage for very often the tree will settle and be too deep. The most important precaution in planting a tree is to get the soil well firmed around the roots. The soil should be worked in around the roots and firmed with the feet. The tree should be planted so that it will be at about the same depth as it stood in the nursery. *Do not plant the tree too deep.*

Cultivation.—The general methods of cultivation suitable for other orchard fruits may be used with almonds. Some people have thought that since the almond will withstand prolonged periods of drought, it will thrive under careless cultural treatment. This, however, is not the case.

A suitable method of soil handling would be somewhat as follows: Plowing should be done in the spring. If cover crops are grown, they should be allowed to grow high in order to provide large quantities of humus. Care must be exercised, however, especially where irrigation is not possible, to prevent the vegetation from exhausting the moisture from the upper soil. The plowing should be done early enough to be followed by one or more good rains. The depth of plowing should be varied from year to year in order to prevent the formation of an impervious plow pan. After plowing, the ground should be worked down, generally with a disc, before the plowed surface has a chance to bake. The conditions and type of soil will determine whether it will be necessary to harrow or possibly roll to firm the soil and break up clods.

Subsequent cultivations will be determined by weed growth and type of weeds. Sufficiently frequent cultivations should be given to keep down weed growth, and if morning-glory is present, it will be necessary to use a weed cutter. By using a weed cutter once a week throughout the season, the morning-glory may be practically eradicated in one season. It is absolutely necessary in order to kill the morning-glory plants, not to allow them to show above ground. It should be remembered that weeds in an orchard, especially an unirrigated orchard, are detrimental, because they extract much moisture from the soil.

Recent investigations indicate that very little moisture is lost through direct evaporation from the soil surface under California conditions. The greatest loss is from transpiration through the leaves of the trees and weeds.

When the land has been plowed and brought to a good state of tilth, little cultivation will be needed through the remainder of the summer, *except to kill weeds,* and put the soil in good condition after an irrigation. Excessive cultivation continued after the surface has been put in good condition is probably a useless expense.[6]

Cover Crops.[7]—Constant cultivation throughout the summer promotes the destruction of the humus and, by hindering the growth of

[6] California Agr. Exp. Sta., Ann. Rept., 1922, p. 104.

[7] For additional information on cover crops see California Agr. Exp. Sta. Cir. 255, 1922, and also California Agr. Exp. Sta. Cir. 257, 1923.

vegetation, prevents the addition of a natural supply of humus to replace that which has been lost.

The plowing under of annual winter cover crops does not entirely replace the humus burned out in the summer, but reduces the annual net loss and at the same time improves the texture of the soil.

Melilotus indica (yellow sweet-clover) is one of the good orchard cover crops. To secure satisfactory growth, it must be planted early (September), a factor which practically prevents its use where irrigation water is not available.

Very often vetch (*Vicia sativa*) will make a good stand when late-planted, though this is not always the case.

In some sections burr-clover is the best crop which can be used. It often reseeds and comes up year after year, especially where fall irrigation is practiced or in regions of early autumn rains. Where no irrigation water is available, the safest crop is probably barley or rye. A rather new but promising cover crop is the small-seeded horse bean which generally grows well in the cold winter months.

In addition to the winter cover crops named above, alfalfa is being successfully used by some growers as a permanent cover or shade crop in old orchards where irrigation is practiced. Too many growers, forgetting that the almond trees are their main crop, irrigate and care for the alfalfa at the expense of their trees.

In some situations alfalfa in almond orchards increases the humidity of the atmosphere sufficiently to aggravate the trouble with shot-hole and brown rot.

The following quantities of seed to the acre should give good results: Melilotus, 20–25 lbs.; burr-clover, 20 lbs.; vetch, 50 lbs.; small seeded horse bean, 35–45 lbs.; barley or rye, 50 lbs.

Irrigation.—Almond growers are becoming more convinced that in numerous orchards irrigation is advisable. This is especially true in bearing orchards where there is a light rainfall. Trees in heavy bearing require more water, necessitating the addition of irrigation to supplement rainfall. Where irrigation is practiced judgment must be used in the amount and frequency of application of water. While definite directions cannot be given as to either, it is probably safe under all conditions to give at least a light irrigation (about two acre-inches) in the fall for seeding the cover crop and also for the benefit of the buds. In early spring if it is found that the winter rainfall has not wet the ground to a depth of six feet, the deficiency should be made up by irrigation. Whether it will pay to irrigate in summer has not been definitely determined, but keeping up the vigor

of the trees throughout the season would no doubt materially aid in controlling the red spider. In dry years a large percentage of the hulls fail to open, making hulling impossible. When the hulls begin to split it is advisable to irrigate. This reduces the number of "stick-tights."

The above discussion applies to middle-aged and old trees. Young trees, eight to ten years old, may do very well without any irrigation whatever if the average rainfall is sixteen inches or more.

Numerous methods of applying water may be used. The check and furrow systems are most generally employed.[8]

Fertilization.—Little or no systematic work has been done up to the present time in the use of commercial fertilizers on almonds. The use of barnyard manure is desirable wherever obtainable. The value of almond hulls as fertilizer is doubtful, because of the difficulty of bringing about their thorough decay. Because of the high percentage of tannin they contain, it is inadvisable to use more of them than would naturally fall from the tree. The use of lime to correct soil acidity and to improve the texture of heavy soils is desirable if the cost is not prohibitive.

PRUNING[9]

Pruning properly begins with the training of the young tree the first summer in the orchard. At the time of planting the tree is generally cut back to a whip about twenty-seven inches long. In rare cases, when good nursery laterals occur where wanted, they may be saved and shortened to eight or ten inches. As a rule, however, all the nursery laterals are cut off. The framework branches must be grown from dormant buds or from adventitious buds which arise around the wounds caused by removing the nursery laterals. In the spring (April or May) much good work in training the framework may be done by going over the trees carefully and selecting the branches desired for the framework. At this time the growth is only a few inches long, and the undesirable twigs are easily subdued by pinching out their terminals. This will encourage the growth of those selected for framework branches. These should be allowed to grow untouched. The undesirable branches should not be removed *entirely* because their leaves manufacture plant food and by shading help to prevent sunburn of the trunk.

[8] For methods of applying water see U. S. Dept. of Agr. Farmers' Bull. 882, 1917.

[9] For additional data on pruning see California Agr. Exp. Sta. Bull. 313, 1922, and also California Agr. Exp. Sta. Bull. 386, 1925.

If a tree is allowed to grow the first summer without this treatment, three to five of the uppermost buds will develop into good strong branches by the end of the growing season, while only short twigs will develop from the buds lower down on the trunk. The latter cannot be used as framework branches. In this case, it will be necessary to select the three framework branches all arising from practically the same point on the tree, a condition which in later years causes crowding and the formation of water pockets (fig. 5).

Fig. 5.—The result of selecting branches arising from one point on a main trunk. In this so-called water pocket note the entire blade of the knife is under water. This photograph is of a ten-year-old almond tree. The trouble is only just beginning, and unless immediate steps are taken for its remedy the usefulness of the tree will be shortened many years. From Bull. 313, California Exp. Sta.

The best type of head is one in which the branches are spaced as far apart as possible along the trunk. The ideal is to have three branches (with more it is impossible to avoid crowding), spaced about six inches apart and arranged spirally around the trunk, forming equal angles of about 120 degrees. The only way to get strong branches where they are desired is to pinch the tips of all badly

placed shoots. This diverts the growth into those suitably placed. It is advisable to go over the orchard again in June to subdue additional undesirable growth.

Pruning One-year-old Trees.—The first winter's pruning may be done at any time after the leaves fall, approximately one year after planting. If summer pinching has been done, there will be very little to do except to cut back the three scaffold branches to from fifteen to thirty inches to a lateral if possible—according to the variety of almond, and the growth the tree has made.

On account of its spreading habit of growth a Drake will have to be headed more severely than an upright variety such as the Ne Plus Ultra or I. X. L. In cases where trees have made a very vigorous growth during the first summer in the orchard, it may be desirable to head them when they have made a growth of fifteen to thirty inches. A secondary branching may thus be secured during the first summer. In this case the first winter's pruning will consist of a thinning only, since a sufficient number of framework branches have been secured (five-seven at about five feet from the ground). If the trees have, for some reason, made very poor growth during the first season, they should receive no pinching out in the summer and little or no pruning in the first winter so that they may have as much leaf surface as possible to build up the tree and make a strong healthy growth the second season.

Figure 6 shows a Nonpareil almond, before pruning, after one season's growth in the orchard. At the time of planting the nursery laterals were saved and headed at "A." Figure 7 shows the same tree as figure 6 after pruning.

Pruning During the Second Season.—When growth starts the second spring, numerous sprouts will be produced around pruning wounds and also from dormant buds where they are not wanted. It is a good plan to go through the orchard in early May or whenever these sprouts are eight to ten inches long and pull off or cut out those not wanted and pinch back those which will make desirable fruit spurs (the less vigorous ones). The removal at this time of undesirable branches which are likely to grow at the expense of the desirable framework branches is also recommended. Since the almond makes numerous lateral branches it is not usually necessary or even desirable to give any heading to the framework branches the second season.

If no spring pinching has been given during the second spring and summer, it will be necessary to remove the watersprouts and ill-placed branches. Occasionally, when a tree has made an unsym-

Fig. 6.—One-year-old Nonpareil before pruning. At the time of planting the nursery laterals were saved and headed at "A."

metrical growth, a watersprout may be used to advantage for a framework branch if growing in the proper position to fill a vacancy. Generally no heading is necessary, especially if the tree has five to seven branches and sufficient spread.

Fig. 7.—Same tree as fig. 6 after pruning. Thinned to laterals and the laterals headed moderately.

Pruning the Third and Fourth Years.—If the trees have been pruned as above outlined (it is assumed that soil, moisture, etc., are favorable for good vigorous growth), the only pruning necessary will

be a thinning out with no heading (fig. 8). These trees should produce a considerable crop of nuts the fourth summer and should thereafter be handled as bearing trees.

Fig. 8.—Nonpareil almond. Three years old. After pruning. Thinned only.

Pruning Bearing Trees.—If young almond trees have been properly trained and pruned, the bearing trees should not be hard to prune. The commercial practice in almond pruning consists mainly in the removal of watersprouts and branches averaging one-half inch

in diameter, no attention being given to the one-year-shoots (fig. 9). Occasionally it will be necessary to remove a larger branch as it begins to interfere or cause crowding. It is necessary to keep the trees open so that the sun can filter down through the leaves and maintain a healthy condition in the lower buds and fruit spurs—otherwise the fruiting area will be confined to the outer area of the tree. This practice also facilitates harvesting. Normally, bearing almond trees are not expected to make more than from eight to fifteen inches of

Fig. 9.—Six-year-old Nonpareil. "Moderately pruned."

new wood growth each year. If trees are making much more growth, it may be advisable to cease pruning for several years. This is likely to throw the trees into heavy production and thus slow down vegetative growth. After regular bearing is established, a moderate pruning should be given to get the trees back into proper shape. On the other hand, if they are making little or no growth, some of the fruiting branches should be removed. This will invigorate the trees (fig. 10). Very often, however, the lack of growth is due to soil moisture conditions and cannot be materially influenced by pruning alone.

REJUVENATION OF OLD TREES

Through one cause or another, old trees sometimes reach a condition where production is so low that they are no longer profitable. The question which confronts the grower is what to do with the trees to get them back to profitable production. If the trees are sound, that is, not affected with severe infections of crown gall or heart rot, and not growing under adverse conditions such as shallow soil, underlying hardpan, or lack of moisture, they can very often be rejuvenated by cultural treatment.

Fig. 10.—Twenty-seven-year old Ne Plus Ultra after having been severely thinned. This tree had not been pruned for six or eight years.

Sometimes a thorough spraying to destroy the pests and the addition of irrigation is sufficient. Very often a more or less severe pruning will be necessary. Generally this pruning should consist of the removal of a considerable number of rather large branches. In order to prevent sunburn, the thinning out and opening up of the trees should be gradual. Frequently the removal of a larger number of smaller branches all over the tree is more advisable than removing a large limb here and there.

Under certain conditions it may be best to dehorn the trees about six feet from the ground and form a new head from the suckers which arise near the end of the stubs. This method is not always satis-

factory, especially in windy sections. The new shoots do not have a very strong union with the stubs and after they come into bearing will, from time to time, blow off.

ORCHARD HEATING FOR FROST PREVENTION[10]

On account of their early blossoming habit the almonds are frequently injured by frost. Recently considerable interest has been shown in methods of protecting them from this danger. The use of orchard heaters in some districts has become a common and successful practice. It is possible economically to control several degrees of frost for three or four or possibly more nights by a judicious use of heaters.

The best type of heater[10] for almond orchards has not been thoroughly worked out as yet. Both the "lardpail" or open type and the improved stack type of heater are being used.

At least seventy-five one or two-gallon lardpail heaters to the acre are necessary to control temperatures as low as 27 or 28 degrees F. Probably not over 100 pots to an acre would be needed at most. A smaller number of the stack heaters are sufficient. Double the number of pots should be placed around the outside especially on the windward side.

The gravity of oil best suited for orchard heating is between 20 and 25 degrees Baumé. It is essential that it be as free as possible from impurities such as sulfur. During the spring of 1917, orchard heating was done very extensively in some districts of the state while the trees were approaching full bloom. As the season progressed, it became apparent that some serious injury had been done by the heating, for the bulk of the blossoms fell off and the leaves turned yellow in streaks as if burned by an acid. It seemed as though the pistils of the flowers and the young leaves had absorbed sulfur dioxide gas (a product of oil combustion, where sulfur is contained in the oil), which in uniting with the dews had formed sulfurous acid, which had done the damage. Had the heating been done only after the trees had passed full bloom, a much heavier set of nuts might have been secured, since the small fruits, where they had formed, seemed to have been uninjured, only the pistils of the flowers having been affected, probably preventing pollination and fertilization of the ovules.

The time of heating is therefore a very important point. Almond blossoms become progressively more tender to frost as they advance

[10] Additional information may be obtained from the Almond Growers' Exchange Bulletin entitled, "Frost Protection—Orchard Heating," pp. 1–8, 1923.

in development. With their petals on, they are not nearly so tender as they are after the petals have fallen. They reach their most tender stage after the calyx shucks have fallen and before the fruits are the size of a pea. Ordinarily, orchard heating before the trees have passed full bloom is a waste of time and material and is often injurious. The most necessary time for heating is usually during the two or three weeks after the bulk of the petals have fallen, unless temperatures below 28 to 29 degrees are encountered before that time. The most complete treatise on orchard heating is U. S. D. A. Farmers' Bulletin No. 1096, entitled "Frost and the Prevention of Damage by It."

CROP HANDLING

Harvesting.—The harvesting of the crop should begin as soon as the hulls have opened to their fullest extent, and no time should be lost in completing the work. The nuts in the center of the tree are the last to ripen and so may be used as indicators. If harvesting is begun too early, the nuts will cling to the tree rather tenaciously and require very vigorous knocking to loosen them. On the other hand, if they are allowed to hang too long after ripening, a number of difficulties may be encountered. They may be blown to the ground by light winds and the cost of gathering be increased, as quite commonly occurs with the Peerless; or the hulls may dry up and in doing so close around the nuts to a greater or less extent and add to the cost and difficulty of hulling. This is most noticeable with the Nonpareil. Strong winds will break off a great many of the nuts of any of the varieties, and promptness is doubly essential where there is any likelihood of such winds occurring during the harvest season. Depredations by birds may cause serious losses, especially with the soft and paper-shell varieties. Infestation by worms may often be quite serious in the papershell varieties, when they are allowed to hang too long. In case of damp or foggy weather, the shells turn dark and sometimes commence to mildew, requiring heavier bleaching to brighten them sufficiently for market demands. Rain stains can never be removed entirely by ordinary bleaching.

The crop is harvested by knocking the ripened nuts and hulls with long poles onto sheets spread on the ground under the trees. The knocking should be done near the portions of the trees where the nuts are borne and by striking a number of light, quick blows, rather than by a heavy blow aimed to jar a large branch. This method avoids injury to the bark by bruising and will accomplish the work in less

time. The blows should always be delivered squarely against the branch. A glancing blow will tear the bark and break off a great many fruit spurs, thus reducing the bearing surface for the next year. For this reason harvesters must be watched closely all the time to insure the proper use of the poles. The sheets, two in number, are spread under the trees so they will overlap and catch all the nuts that fall (see fig. 11). When sufficiently loaded with nuts to make dragging the sheets from one tree to another difficult, they are emptied into lug boxes or bags and sent to the huller.

Fig. 11.—Harvesting almonds by knocking onto sheets spread on ground.

The character of the harvesting equipment may vary considerably, according to the acreage, character of trees and ground, time required, capital available, and the ideas of the owner. Some growers use heavy poles of pine, spruce, or fir, while others prefer the lighter bamboo poles. The heavy poles are from 1½ to 2 inches in diameter at the base and from ¾ to 1 inch in diameter at the top. Experience has shown that poles of this type over 20 feet in length are unwieldy, and not only swing slowly but do more damage because of the greater difficulty of control. Most growers prefer 16-foot poles with a few 20-

foot ones for use in the tops of the taller trees. Where the tops cannot be reached with these, the men climb into the trees with shorter poles. The bamboo poles used are about 24 feet long, and because of their lightness, can be used with greater speed. Bamboo poles with short internodes should be selected, as they are less likely to break. Breakage may also be reduced by storing the poles in a cool place where drying-out will not be excessive.

The sheets, which are made of 7 to 12-ounce duck, range in size from 12 by 24 to 24 by 48 feet. They need not be much longer than the longest diameter of the tree. To prevent mildew and rotting of the fabric, the sheets should be boiled in a solution of tannin before being used. Sheets thus treated last much longer.

Some growers have contrivances by which sheets are mounted on sleds or wheels. The principal objection to such an arrangement is that the sled or wheeled frame must be made in two sections, one for each side of the tree, which increases the cost of the operation because the horses can be used for nothing else while the harvesting is in progress. On the other hand, when moved by dragging on the ground, sheets will wear out in two or three seasons, while with the sled or wagon method they will last from six to ten years longer. The two wagons shown in figure 12, each 12 by 24 feet, cost between $60 and $70 about the year 1914. The canvas portion is of 8-ounce duck.

Fig. 12.—Portable almond sheets mounted on wheels as used by N. J. Lund, Oakdale, California, 1916.

By this method the knockers can gather ten lug boxes before emptying. The work can be done much faster with wagons. When sleds are used, one sheet is fastened lengthwise on the right side of the left-hand sled and another on the left side of the right-hand sled. More recently, single sleds have been devised with the two sheets extending lengthwise on either side of the tree. The Division of Agricultural Engineering of the University of California have available plans and specifications for such a sled.

Hulling.—After harvesting, the almonds, hulls and all, are taken to the huller while still moist. If they become dry before hulling they must be dipped in water or the shells will be broken. All hulling was formerly done by hand, and this is still done where only small lots are to be handled. The invention of machinery for this purpose has reduced the cost of hulling from 60 to 80 per cent, for most outfits separate the hulls from the nuts before they leave the machine. Some of the hand hullers consist simply of the hulling portion of the large power machine without the separating screens. These cost about one-sixth or one-seventh as much as the large machines, and where a man has a small acreage and is too far away to haul to a large huller, a hand machine will greatly facilitate the work, even though the final separation must be done by hand.

There are many different kinds of hulling and separating machines now in operation in California, all invented by California almond growers. The first one made was the Read "Sure-Pop" almond huller. This is now manufactured in three sizes by the Schmeiser Manufacturing Company, Davis, California. The No. 3 huller, which is generally best for orchards of less than ten acres, may or may not be equipped with a separating device. If it has no separator, it may be operated by hand; otherwise a small engine or motor is needed. The No. 2 hullers both hull and separate and are operated only by power. They should pay in orchards of ten acres or more. The No. 1 is the largest made and is for use in orchards of 100 acres or more.

The Beach huller is of more recent origin, having been in use only since 1895. It was invented by J. E. Beach of Fairoaks, California, and is being manufactured by him. Both sizes of this machine are power outfits; they are doing satisfactory work at the present time.

A third huller is that made by C. U. Reams of Suisun. More recently, hullers have been invented and are being manufactured as follows:

The Miller Huller, manufactured by L. L. Miller, Ripon, California.

The Stephens Huller, manufactured by the Bean Spray Pump Company, San Jose, California.

The Martinette Huller, manufactured by F. L. Martinette, Chico, California.

The Vaughan Huller, manufactured by L. K. Vaughan, Woodland, California.

An unnamed huller, manufactured by Smith Manufacturing Company, San Jose, California.

The efficiency of these hullers depends largely upon the speed of the machine and upon the condition of the almonds in the hulls. If the machine runs too fast, the almonds are broken and injured, and if it runs too slowly, many of the almonds are not hulled. If the almonds are allowed to hang on the trees too long, the hulls become dry and leathery, and the difficulty of hulling is greatly increased. Dipping in water in such cases may help to overcome this difficulty to a limited extent.

The papershell varieties, notably the Nonpareil, are much more difficult to hull without breaking the shells than are the harder shelled varieties. The Nonpareil hull has a tendency to close around the nut on drying, making hulling very difficult.

Often when the moisture supply in the soil is exhausted before the nuts are ripe, or when the loss of leaf surface due to mites is serious before ripening, the hulls open only slightly or not at all, but dry onto the shell of the nut. Such "stick-tights" can be disposed of profitably only by allowing them to dry thoroughly, after which they are cracked and sold as "meats."

After the hulling operation, all almonds must be gone over by hand to remove pieces of hulls and inferior or gummy nuts. Where canvas drapers are not available for sorting directly from the huller, the nuts are piled in hoppers and sorted on benches beneath them.

Drying.—Immediately after the sorting, the nuts are spread on trays and thoroughly dried in the sun. In the interior valleys during hot, dry weather the nuts will sometimes dry so quickly that by the time the sorting from hoppers is completed, the nuts are sufficiently dry. The grower must be certain, however, that such is the case before the almonds are delivered to the warehouse. The nuts are sufficiently dry when the kernels will break without bending. Quick drying seems essential to prevent the excessive darkening of the shell.

Bleaching.—The trade demands an almond with a bright golden-yellow shell. In the earlier history of the almond industry, the growers bleached their own almonds. As a consequence, there was no uniformity in the product. At the present time the associations advise that the almonds be delivered unbleached, as they have perfected machinery for bleaching and are thus able to produce a uniformly bleached product.

Their method in general consists of subjecting the almonds to a low steam pressure for 10 to 20 minutes in order to moisten the shell. They are then exposed to sulfur fumes for 10 to 30 minutes. One to three pounds of the best grade of flowers of sulfur is necessary to bleach one ton of almonds. Proper bleaching does not affect the almond in any way. However, over-bleaching produces a sickly yellow or whitish colored shell and also causes the kernel to deteriorate and become rancid.

Sacking.—During the preliminary handling of almonds, ordinary grain sacks are commonly used. After bleaching, in which condition they are ready for market, they are put in standard almond bags, measuring 20 by 40 inches and weighing 1¼ pounds. The weight of a bag of almonds varies not only with the variety but also with the year and locality in which it is produced. For selling purposes the California Almond Growers' Exchange estimates weights of different varieties to be as follows: Nonpareil, 85 pounds to the bag; I. X. L., 80 pounds; Ne Plus Ultra, 75 pounds; Drake, 90 to 100 pounds; Languedoc, 100 pounds; and hardshell almonds, 100 to 120 pounds. The bags will be changed with the 1924 crop, and will measure 28 by 40 inches, and weigh, when filled, about as follows: Nonpareil, I. X. L., and Ne Plus Ultra, 85–90 pounds; Drake, 100 pounds; Texas, 105–110 pounds; hardshells, 120–130 pounds.

Shelling.—The increasing popularity of shelled almonds, and the limited market for unshelled ones during the past few years, have made it imperative to give attention to methods of shelling. The California Almond Growers' Exchange has perfected machinery which together with increased tariff duties has enabled it to market large quantities of shelled almonds during the 1923–24 season. Thus there was but little carry-over into the 1924 crop season and none into the 1925. A small proportion of the shelled almonds marketed—usually not more than thirty pounds to the ton—are accidentally shelled during the hulling process.

Recently a large proportion of the Texas variety has been shelled and sold successfully.

Papershells, however, are the varieties most commonly marketed in this way, for two reasons: (1) their kernels do not break so readily in the shelling process, and (2) the percentage of kernel is much higher than in the harder shelled varieties.

Grading.—Though grading almonds for size is not practiced at present, it probably will be within the next few years. Grading for quality, however, is done regularly by testing an entire lot rather than by attempting to separate inferior nuts. All lots free from worms or gummy nuts and having a required percentage of good kernels—90 to 95 per cent, according to the conditions of the market and of the crop as a whole—are considered standard grades, and are sold on guarantee. All lots which cannot pass this test are sold on sample, and therefore, on their own individual merits.

MARKETING

Exchange Organization.—The marketing of the almond crop of California is at present on a firmer basis than at any time in the past. Before 1910 there was little or no coöperation among growers, and the buyers had everything their own way. In May of that year, however, Mr. J. P. Dargitz, an almond grower near Acampo, California, successfully organized the California Almond Growers' Exchange, consisting of nine local sub-associations, with a total membership of 230 growers. The Exchange started business with $1000, borrowed capital, personally guaranteed by the directors. On June 1, 1918, there were twenty-two sub-associations representing about 2000 growers, and controlling about three-fourths of the crop. On April 1, 1924, the association had a membership of 3359, controlling 70 per cent of the crop. All members are on a five-year contract basis. The Exchange now is not only out of debt but has assets of about $400,000, including warehouses, a central shelling plant, and other property. At the same time, the growers have been receiving about 50 per cent more for their almonds then before the Exchange was organized.

The success of the Exchange, with the consequent higher prices to the grower, has resulted in a large increase in the acreage of almonds in California. This increase is making it necessary to develop new markets to absorb the consequent greater tonnage, which can be done satisfactorily only by coöperative effort.

Until 1923, California almonds were marketed chiefly in the shell, though a small quantity had been cracked annually to supply west-

ern brokers and confectioners. Virtually all of these were sold west of the Rocky Mountains. During the 1923 crop season, however, the Exchange sold over 1,300,000 pounds of shelled almonds.

European Competition.—European growers who send their crops to the United States largely as "meats" had practically a monopoly of the shelled almond business until 1923. The unshelled Tarragonas, Princess, etc., shipped to America come into direct competition with the I. X. L., Drake, Languedoc, and other California almonds, all of which are unshelled. The amount of unshelled almonds imported is about equal to the California production. The Jordan, Valencias, and other varieties constituting the bulk of the importations, however, come shelled. The Jordan, because of its superior quality, is almost in a class by itself and does not at present cause serious competition with the California product. The Princess and other almonds of the same type are very similar to the California shelling varieties and are serious competitors when offered in the same markets.[11]

Storing.—Almonds become rancid if stored in warm or damp places. If they have been properly cared for during the handling process to prevent worm infection, and have been thoroughly cured, however, they will keep satisfactorily in suitable storage for a year or more while awaiting removal or sale. The places where they are stored should be uniformly cool, dry and with ample ventilation.

COST OF PRODUCTION

The amount and kind of equipment of the average almond orchard is extremely variable. The larger and more progressive orchards are usually well equipped with all the necessary tools and power. Many small growers, however, can not afford all the machinery necessary for running their places. Most orchardists have their own tillage and harvesting equipment, though some prefer to depend upon their neighbors to do their hulling by contract.

In addition to the ordinary orchard equipment, the almond grower needs special equipment for harvesting, hulling, and drying. This includes canvas sheets, poles for knocking, lug boxes or sacks, a huller, sorting tables or bins, trays, and sacks for delivery to the warehouse. Sheets cost from $20 to $100 according to the size and quality; poles 15 cents or more; lug boxes 35 cents; hullers $150 to $1200; trays

[11] The increasing popularity of shelled almonds makes it advisable that the American markets be made familiar with the California shelled product, and that its sale be extended as quickly as possible. This is indeed necessary because it has been found impossible to dispose of the whole of the present annual production in the shell, and the prospects are for a greater production in the near future.

about 75 cents; sacks about 15 cents; sorting tables or bins are generally made by the grower at the cost of material and making.

The average cost of harvesting (knocking, gathering, and delivering to the huller) is about three cents a pound, and the cost of hulling and drying about two cents a pound. The harvesting costs vary greatly, largely according to the size of the crop. The smaller the crop the greater the proportionate cost.

The cost of orchard operations varies with the prevailing wages. Cultivation, including plowing, probably costs $15 an acre; spraying about $10 an acre; pruning and burning brush, about $7; and irrigating, if practiced, about $8 an acre.

To these costs must be added taxes, insurance, upkeep of tools, depreciation on equipment and buildings, cost of feed, and interest on the investment.

Yields.—The yield of almonds in different years and in different orchards is probably more variable than that of any other of the common orchard fruits. While the fluctuations from year to year are largely due to climatic conditions, the variations in orchards are due largely to variety, care given the trees, character of soil, and frost conditions.

Almonds begin bearing at from two to four years, the first crop ranging from one or two nuts up to a hatful, or possibly more. At three to five years, they should yield a crop which will pay for harvesting. Ordinarily, the first crop that it will pay to harvest is not obtained until near the latter age, though this depends upon the type of soil in which the trees are growing and the moisture conditions surrounding them. On the hill lands the trees begin to mature much earlier than in the rich bottom lands, and consequently come into bearing earlier. It must be borne in mind that a crop which it will pay to harvest does not necessarily mean a paying crop. It does not become a "paying crop" until it covers the cost of maintenance as well as of harvesting and handling. Almond orchards, as a rule, reach this point in from five to seven years. From this time the trees should continue to increase in production from year to year, allowing for failures due to frost and unfavorable conditions, until they are from twelve to twenty years old. Under the common methods of care that most orchards receive, the trees begin decreasing in production after twenty-five to thirty years, and in some cases earlier. On the other hand, orchards that are well cared-for often continue their maximum production even longer. The age at which an orchard will not longer pay ranges from thirty years upward. The limit is still unknown.

Investigations carried on during 1913–14[12] brought out the following facts: The average production of almonds in California is between 700 and 800 pounds per acre; if care is exercised in the selection of a proper location for an orchard and if good judgment is used in managing it, 1000 pounds per acre would be a safe estimate for business purposes; in many years competent orchardists may expect to obtain 1500 pounds per acre, but this would not be likely for a ten-year average. The possibilities are indicated by the crop from one acre, on the University Farm at Davis, California, of ten-year-old trees which produced nearly 2800 pounds in 1917.

TABLE 3

Net Prices (in Cents per Pound) Realized by the Exchange Members for Different Varieties for the Years 1910 to 1923, Inclusive

Year	Nonpareil	I. X. L.	Ne Plus Ultra	Drake
1910	14.00	13.00	12.00	10.00
1911	16.50	15.50	14.50	12.00
1912	13.25	12.25	11.25	9.50
1913	17.25	16.25	15.25	13.25
1914	18.00	15.00	14.50	11.50
1915	13.00	12.00	11.00	9.25
1916	17.25	14.75	13.75	13.00
1917	17.50	16.00	15.00	12.50
1918	24.00	22.00	21.00	17.00
1919	26.00	24.00	21.00	14.00
1920	18.50	18.50	16.50	9.00
1921	18.00	17.00	16.00	9.00
1922	20.00	18.00	16.00	11.00
1923	15.00	13.00	13.00	8.00
Average	17.73	16.23	15.05	11.36

Returns.—Prices paid to growers have fluctuated considerably on account of the great variation in both the Californian and European crops from year to year. Table 3 shows the average price paid to the growers for the four principal varieties marketed through the Almond Growers' Exchange since its organization.

Table 4 shows the average price per pound paid to the growers for all almonds (unshelled), including all qualities and the entire crop handled by the Exchange during the years 1910 to 1923 inclusive.

From these figures it has been found that the average return per pound for all varieties for fourteen years based on the crop tonnage

[12] California Agr. Exp. Sta., Cir. 121, 1914.

for each year, 1910 to 1923, inclusive, was 13.98 cents. It is interesting to note that the 1923 crop is the largest produced in the state and also that the average price paid growers is practically three cents less than the average for the fourteen years.

TABLE 4

AVERAGE PRICES PER POUND PAID GROWERS FOR ALL UNSHELLED ALMONDS FOR THE YEARS 1910 TO 1923, INCLUSIVE

Year	Price per Pound, Cents	California Crop, Tons
1910	12.00	3,300
1911	13.50	1,450
1912	11.00	3,000
1913	15.50	1,100
1914	14.05	2,250
1915	10.75	3,500
1916	13.97	3,400
1917	14.23	4,000
1918	19.81	5,100
1919	19.01	7,250
1920	13.48	5,500
1921	13.40	5,500
1922	14.06	8,500
1923	10.98*	11,000
Average	13.98	4,632

* Estimated.

ALMOND DISEASES AND PESTS AND THEIR CONTROL

DISEASES

Crown-Gall.—This disease, which is also known as root-knot or black-knot, is one of the most serious with which the grower has to contend. It is found practically everywhere that almonds are grown, and either greatly reduces the vitality of the trees affected, or kills them, according to the seriousness of the attack. The name "root-knot" is more commonly applied to root swellings caused by nematodes.

Crown-gall is caused by a bacterial organism, *Bacterium tumefaciens* S. & T., that seems to be native to most California soils. It is characterized by large swellings on the root crown or main roots just below the surface of the ground, though milder infections may sometimes be found also on the smaller roots. When cut open, the

knots appear spongy as if the bark and wood were mixed together in one mass. They are most serious when spread over a large surface, either partially or completely girdling the root or crown of the tree.

Control methods are of two kinds:

(1) Nothing but clean, healthy nursery trees, free from all trace of galls, should be planted. All broken or injured roots should be carefully trimmed off, leaving nothing but smooth, clean cut ends which will heal over readily with the minimum opportunity for infection.

(2) Galls on orchard trees may be cut out to clean, healthy wood with a sharp knife or gouge chisel. The wound should be thoroughly disinfected with a strong (5 to 10 per cent) copper-sulfate solution or a mixture of corrosive sublimate and mercury cyanide, 1 part of each to 500 parts of water by weight, and painted when the surface is dry with a protective covering such as a lead and oil paint or melted asphaltum, or it may be covered directly with Bordeaux paste. The earth should be replaced over the roots. The trees must be reinspected carefully and any new galls which have formed at the wound margin removed and the new cuts disinfected.

The use of resistant stocks has been suggested as a means of avoiding infection, but no such stock suitable for the almond has yet proved to be sufficiently resistant under average conditions to be safely recommended. The greatest hopes for future success in combating this disease, however, lie in this direction.

Oak Fungus.—This is one of the most difficult diseases to control because it works and spreads beneath the surface of the ground in the roots of trees. In some sections of the state it is very serious.

The disease, often called root-rot, is caused by a fungus, *Armillaria mellea,* commonly called "toadstool" fungus. It is known as oak fungus because the disease is most commonly found on land where old oak trees have stood. Where orchards have been planted on such land, spots appear in which the trees gradually die, the disease spreading from tree to tree, in ever-widening circles which take in ordinarily about one row of trees each year. During the winter, clusters of toadstools may be seen at the base of the affected trees. The fungus lives over in the old oak roots for many years and, as the orchard becomes well established, spreads to the almond roots. If not checked, the spot will eventually involve the entire orchard and prevent further growth of almonds on the land for many years.

The only remedy known is to construct barriers around diseased spots, and thus prevent the infection from passing beyond through

the roots. The spread of the disease may sometimes be held in check by grubbing out a row or two of healthy trees outside the affected area and taking care that all of the large roots are removed to a depth of several feet.

There are no resistant stocks known at present upon which the almond can be worked, but the fig, pear on French stock, and walnut on Northern California Black Walnut stock may safely replace the almond in affected spots.

Shot-hole Disease.—There are three different fungi that produce the shot-hole effect on the leaves of the almond.

(1) *Coryneum beijerinckii* Oud, or peach blight, is the most common form. It is not so serious on the wood of the almond as it is on that of the peach, but in seasons of damp spring weather it does much damage to the blossoms, fruits, and leaves. Affected blossoms are killed outright, the flowers turning brown and dropping much as if killed by frost. The young fruit is spotted by the fungus, which causes malformation, gumming, and shriveling of the nuts, varying with the severity of the attack. On the leaves many small dead spots appear, the dead tissue soon falling out and giving the shot-hole effect. Where the twigs are affected, small dead spots appear during the the winter, most often at the buds. This causes the death of the buds and often the ends of the twigs. During the spring, after growth starts, gumming occurs at these spots.

Only two sprays are known to give effective control—Bordeaux mixture and lime-sulphur (winter strength). One or the other should be given in the fall, as soon as the trees become dormant, and again just before the buds open in the spring. Both the fall and the spring sprays must be thoroughly applied to be effective.

(2) *Cercospora circumscissa* Sacc. is another fungus causing much the same effect as the *Coryneum.* It is difficult for an untrained person to distinguish between them. The same sprays used for Coryneum are effective in controlling the *cercospora,* though if this form alone is present the spring spraying alone should be sufficient.

(3) *Gloeosporium amygdalinum* Brizi, while apparently uncommon in this state, has been found to exist in some places. Its behavior and the most satisfactory methods of control are not exactly known, but it is believed that the control measures mentioned for the other forms of "shot-hole" are also applicable to this.

Brown Rot (*Sclerotina cinerea* Wor.) is a fungous disease which attacks all stone fruits including almonds. The flowers are susceptible

when the petals show in the buds and remain so until the "jackets" (calyx and other flower parts) are shed from the fruit. The fungus grows down through the fruit into the twig. The inner bark turns brown, and copious amber gumming generally occurs. Long shoots may thus be killed by girdling. The fungus remains alive in the dead twigs which serve as a source of infection the following spring. The disease is rarely serious except near the coast and then only in seasons when wet weather comes at the critical time.

During the fall all dead twigs should be cut out and destroyed. Where the disease is serious, a Bordeaux 8–8–50 or a lime-sulfur 1–10 spray should be applied during the bud stage as the petals are showing. (Lime-sulfur is preferable, especially when the twig borer and almond mite eggs are present.)

Prune Rust (*Puccinia Pruni* Pers.).—This fungus is worst in the southern coast sections where almonds are not extensively grown. It is not serious on thrifty trees well supplied with moisture. It is characterized by reddish pustules on the under sides of the leaves, appearing generally about July or August and causing a premature yellowing and dropping of the leaves. No method of control is known.

Heart Rot.—This is one of the most insidious of tree diseases, for it works inside beneath an apparently healthy exterior until the decay has progressed so far that the tree commences to break down, and then it is too late for remedial measures. The almond is not so susceptible to this as most other kinds of orchard trees, but where large wounds have been exposed to the weather, infection may take place readily; and after it is once well started, it continues at a comparatively rapid rate. Decay is caused in most cases by one or more of about a dozen different fungi, of which the oyster-shell fungus is by far the most common.

Control consists in taking care to leave no open wounds exposed to the air to dry and crack and thus permit the entrance of decay organisms. Much of this can be avoided by care in pruning the young tree so that the removal of the large limbs will not be necessary later on. Where such wounds must be made, measures should be taken to prevent infection. This can be done best by making smooth, clean cuts close to the part from which the branch arises. Such cuts heal over more quickly than stubs which dry and crack and sometimes do not heal over at all. All such wounds which do not heal over the first season should be covered with some good disinfectant, such as corrosive sublimate, 1 part to 1000 parts of water, or Bordeaux paste.

When well dried the wound should be painted over with some elastic coating, such as "Flotine," grade D asphaltum, or a good white lead paint applied with a brush. The entire wound must be covered or the work is largely wasted.

Die-back.—This is often serious in orchards where the moisture is insufficient to carry the trees through the growing season. Unfavorable soil conditions, such as hardpan, gravel or sand, may be the direct cause of such moisture shortage. Lack of soil fertility is also a common cause. Control measures consist in remedying the defective conditions. Where this cannot be done economically, it is better to abandon further attempts at almond culture on such land.

Sour-sap.—This is one of the so-called "physiological diseases" and is quite common in the almond. It is most frequently found where trees are planted in heavy or poorly drained soils. The fact that the almond cannot endure standing water around its roots for any length of time, particularly after growth commences in the spring, renders it especially liable to soursap in soils where excess water from the late winter and spring rains cannot be readily drained away. Sudden changes in weather from warm to cold after growth commences are the direct cause of the trouble. The flow of sap is checked very suddenly and stagnation, cracking of the bark, and fermentation ensue. With an unusually strong flow of sap in trees in wet soils, such climatic changes cause unusually severe disturbance in the normal functioning of the trees.

The affected trees ordinarily show the disease first in the spring, when gum may be seen oozing from the bark of the trunk or main branches, and sometimes even from the smaller ones. Small or large branches, and in severe cases, the whole tree, may die soon after beginning to leaf out strongly. When the bark is cut through to the wood and peeled back a strong sour odor is noticeable. The cambium layer appears brownish or reddish in color, and often masses of gum are found between the bark and the wood. Mild cases may not be serious enough to show on the outside of the tree and only portions of the cambium layer may die. The sudden dropping of the blossoms or young fruit may in some instances be attributable to sour-sap.

All affected parts on smaller branches should be cut back to healthy wood, while on the main branches or trunk, where only a small portion or one side is affected, it is best to clean out the dead bark and paint the bared wood with a protective covering until new bark can cover the spot. At the same time, every effort should be made to remedy the soil moisture conditions which were largely responsible for the trouble in the first place.

Fruit-drop.—The same conditions which cause sour-sap may cause fruit drop. Lack of pollination due to improper mixing of varieties or to rain during the blossoming may be another cause. Frost may also produce the same thing by killing the germ in the young fruit. In such cases, the fruit may not fall from the tree for one or two weeks after the injury occurs, and in some instances, may even appear to continue its development for a short while.

INSECT PESTS

Mites.—Commonly called red spiders.[13] There are three kinds of mites that do much damage in almond orchards, the brown or almond mite, the common red spider or two-spotted mite, and the European red mite.[14] These are common in all parts of the state and the first two are the worst pests the almond grower has to face.

The brown mite (*Bryobia praetiosa* Koch), which does not spin a web, is dark red or brown in the adult stage, has very long front legs, and a flattened back. It works on the green bark of the small twigs as well as on the leaves, sucking the plant juices from beneath the bark. The leaves become mottled and eventually fall, although not to such an extent as when attacked by the two-spotted mite. The injury to the tree is just as great because of the serious drain on its vitality and because of the earliness of the attack, most of the injury being done in the spring and early summer. This mite may spend its entire life on the tree; the very small, round, red eggs being laid most often on the under-side of the branches and in cracks and crevices in the bark and twigs. These remain on the tree throughout the winter and hatch early in the spring soon after the trees have their leaves half developed, leaving the white egg-shells in place.

The brown mite may be controlled satisfactorily in the egg stage by means of a dormant spray of lime-sulfur solution, one gallon to nine gallons of water, applied just before the buds open in the spring. Crude oil emulsion as a dormant spray is also effective, if thoroughly applied over the entire tree under high pressure. The lime-sulfur spray should be used in the same way.

During the growing season a milder material must be used. Dry dust sulfur, using only the very finest grade of "flowers of sulfur," is often very effective, provided weather conditions are satisfactory. It must generally be applied several times, however, if the best results

[13] See also California Agr. Exp. Sta., Bull. 347, 1922.

[14] Formerly called the citrus mite.

are to be obtained. The work is done by blowing the sulfur dust into the tree with blowers in the early morning when there is little or no wind.

A more satisfactory method is to use 5 pounds of sulfur, ½ pound of casein spreader, and 2 gallons of liquid lime-sulfur to 100 gallons of water in cases where no winter treatment has been used, or where there are no serious attacks of either of the other two species of red spiders.

The common red spider or two-spotted mite (*Tetranychus telarius* Linn) is of a pale yellow color with occasionally a reddish tinge and sometimes two darker spots on either side of the body. It is a web-spinning species. Unlike the brown mite, it spends the winter and early spring on weeds and hardy cultivated plants. During the warm days of early summer, generally in June, the mite makes its appearance on the trees, spinning a fine web on the leaves, generally on the upper surface, and then working under this web. The mite sucks the plant juices from the leaves, giving them a yellowish mottled appearance. These leaves soon die and drop to the ground. In serious infestations the trees are often almost completely defoliated by the end of August (see fig. 13).

The use of dormant sprays is not effective for controlling the yellow mite, but the summer sprays mentioned above are all satisfactory, and for the best results must be applied under high pressure, preferably 200 pounds or more.

The citrus mite (*Paratetranychus pilosus* Can & Tanz) spins a web, but is generally less abundant on almonds than either the brown or the two-spotted mite. The life-history of this mite is similar to that of the brown mite in that the winter is spent in the egg stage on the host of the previous summer.

This mite is of a deep red color and is much smaller than the almond mite. It is almost too small to be seen with the unaided eye. The sprays mentioned above will control the citrus mite.

Peach Twig Borer[15] (*Anarsia lineatella* Zeller).—In the larval stage these borers work on the young buds, shoots, and fruits. In the early spring they are especially troublesome in newly planted orchard trees when a comparatively small number may kill most of the new shoots which are needed to make the desired framework of the tree. In some years they may be serious in large trees also. Dormant spray of lime-sulfur, 1–10, applied under high pressure just as the buds are opening in the spring will generally control the borers. However, in

[15] See also California Agr. Exp. Sta., Bull. 355, 1923.

Fig. 13.—Nonpareil almonds. Branch on left free from Red Spider and holding its full supply of leaves in green, healthy condition; branch on right defoliated by Two-spotted mite. Note premature ripening of nuts on defoliated branch.

serious infections the addition of three pounds of basic arsenate of lead to every 100 gallons of spray is advisable. This same spray may be used to control the brown mite, thereby accomplishing double control.

California Peach Borer (*Aegeria opalescens* Hy. Edw.).—The larvae are serious in many parts of the state where they burrow just under the bark near the surface of the ground. They may be detected by the small bits of frass and gum at the entrance to their burrows. If allowed to continue, they will eventually girdle the tree.

The surest means of control is to dig out the worms with a knife or to kill them with a wire probe. This work should be done systematically in the fall and spring and the wounds painted with a good asphalt paint. Use para-dichlorobenzine in summer and fall.[16]

Thrips (*Taeniothrips inconsequens* Uzel.).—These are most serious on the almond leaves, their attacks sometimes causing considerable defoliation in late spring or early summer. They may be controlled by spraying with distillate, to which has been added "Black Leaf 40" (40 per cent nicotine) at the rate of 1 part to 1500 parts of water or other spray mixtures. It is possible that some insects other than the pear thrips do similar damage, but the spray described above should be effective against all.

Scale, aphis, diabrotica, and other insects are sometimes found on the trees, but are generally not sufficiently troublesome to require special attention. Most of them are held in check by the control measures used for the more serious pests.

Indian Meal Moth (*Plodia interpunctella* Hln.).—The larva of this moth feeds on the kernels of the harvested almonds after they are stored. Infestation usually takes place in storerooms or warehouses in which the nuts have been placed for a time. The warehouses become infested from old grain bags which have been kept there previously. So far as known, infestation does not take place in the field. The larvae continue to work in the stored almonds for a long time, doing a great amount of damage. They may be controlled by thoroughly cleaning out the corners of the warehouse and thoroughly disinfecting. The nuts should be disinfected with carbon bisulphide (explosive when in the form of a gas mixed with air), or by other means used to control insects in grain. Prevention is far easier than cure in this case.

[16] See also California Agr. Exp. Sta. Cir. 265, 1923.

SPRAY PROGRAM

Under most conditions the following spray program is recommended:

First Application.

In late winter before the buds open, with commercial lime-sulfur, winter strength, for almond shot-hole fungus, brown mite (red spider) eggs, moss and lichens and soft-bodied insects. Crude oil emulsion is more effective against red spider eggs than is lime-sulfur solution.

Second Application.

In summer when two-spotted mite (red spider) appears, about June 1:

Flowers of sulphur—5 pounds.
Casein spreader—½ pound.
Liquid lime-sulfur—2 gallons.
Water to make—100 gallons.

Spray early, before red spider become numerous and as often as necessary.

Additions or Modifications.

In certain sections where shot-hole fungus is serious a fall application of Bordeaux mixture is recommended.

Where the peach twig borer is serious it is advisable to delay the late winter lime-sulfur spray and add 3 pounds of basic arsenate of lead powder per 100 gallons of solution.

OTHER PESTS

Grasshoppers.—Grasshoppers have been serious in orchards in outlying foothill districts in some years, and especially in young orchards, making it almost impossible to get trees started properly. In such locations special means must be employed on a large scale to protect orchards from their devastations. Of these poisoned bait and hopper dozers are the most effective.

Gophers.—These often do great damage to the trees by girdling just below the surface of the ground. Even if they do not actually girdle the trees, the injury may be sufficient to devitalize the tree; in addition, the wounds made by their gnawings frequently become infected with crown-gall. The only safe means of control known is the constant use of traps supplemented by poisoned bait.

Squirrels.—Squirrels are very troublesome, as they harvest a large amount of almonds before they are sufficiently ripe to be harvested by the grower. The use of poisoned grain or "gas," if used over a large area of surrounding territory, will prevent serious depredations.

Birds.—Birds also carry off large amounts of almonds if the orchards are near open country or hills, especially if wooded. Crows, bluejays, blackbirds, yellow-hammers, robins, and others are the worst offenders. Sometimes linnets eat off large numbers of fruit-buds in the spring in some of the newer sections where plantings are scattered. Sap-suckers have been known to girdle entire trees or large branches by boring holes around the trunk or limbs. Generally the damage from birds does not warrant any control measures.

Morning-Glory.—This is probably the worst of the weeds of almond orchards, and is the hardest to control. Sheep and chickens may be used with excellent results, provided care is taken to see that the sheep are not allowed to go hungry, for then they will bark the trunks of the trees very quickly. An excellent plan is to arrange gates so that the sheep must go through the orchard from pasture to get water. In passing back and forth they will forage over the entire orchard and dig up all the morning-glory in sight. Chickens are fond of the succulent new shoots, and will keep them below the ground until the underground stems and roots weaken and die. Cultivation throughout the growing season, often enough to prevent the morning-glory from developing any leaves for a whole year at least, and longer if necessary, will starve the plants to death.

VARIETIES[17]

In selecting varieties of almonds for planting in California the grower should choose those that are most marketable and that at the same time secure the best results in cross-pollination. At the present time there are comparatively few varieties of almonds which have won and retained their popularity with both the grower and the trade. There are a number of reasons for this condition. The cultural, climatic, and soil conditions under which the almond thrives are much more limited than for most of the common deciduous fruits; the area of production in America is limited largely to California; the industry is comparatively new, and in general, there is not the great

[17] Detailed description of varieties may be found in "Almond Varieties in the United States, U. S. D. A., Dept. Bull. 1282, 1924.

varietal variation in season, appearance, texture, flavor, and behavior that is found in the apple, peach, pear, and similar fruits. With almonds, the season of all varieties extends from one harvest to the next, if properly handled. Growers are, therefore, recommended to plant only standard, marketable varieties so far as possible.

Early ripening varieties are best. The crop should be in the hands of the trade early, for the bulk of it is used in the holiday trade. This is especially true of unshelled almonds. Moreover, only early almonds can be harvested and sold before the bulk of the European shipments arrive.

The same variety often ripens at slightly different times in different seasons, in different sections and even in different orchards in the same season. Generally, harvesting commences early in August and closes about the middle of October. The approximate order in which the better known varieties ripen is shown in table 5.

TABLE 5

APPROXIMATE ORDER OF RIPENING OF VARIETIES OF ALMONDS

1. Nonpareil	4. Peerless	5. Golden State
2. I. X. L.	Princess	6. Lewelling
Eureka	California	7. Drake
Jordan	King	8. Languedoc
3. Ne Plus Ultra	Silver	Texas
		9. Reams

Many new varieties have been originated in California, but most of them have fallen into disfavor in a short time. In fact, it is impossible now to find even single trees of some varieties which were formerly well known. From time to time, however, worthy varieties have been introduced and have succeeded in making a permanent place for themselves through their ability to fill a demand that before had been but partially or poorly supplied.

In view of the changing market situation for California almonds, due to the rapidly increasing acreage and to the very limited demand for unshelled almonds, it is safe to predict that the only new varieties which will be of value in the future will be those that are primarily of superior quality for shelling purposes. Yield must take second place.

Well-known varieties are not only in greater demand in the principal markets, but they invariably bring much better prices than the newer varieties. In some years, when the domestic crop of a given

variety is light and the demand good, it is possible to unload poorer or less known varieties at fairly good prices. More often, however, they are a drug on the market.

All varieties will vary in size from season to season and in different orchards during the same season, according to the plant food and moisture supply available during the time the nuts are maturing.

Fig. 14.—Typical Nonpareil almond tree in University Farm orchard; nine years old. Note numerous watersprouts which must be removed.

Some varieties, notably the Nonpareil, vary more in size than in plumpness, while others, like the Ne Plus Ultra, are more inclined to produce somewhat shriveled kernels and imperfectly developed shells though the variation in size will not be so great. As the yields become heavier, the nuts are likely to be smaller. Young, vigorous trees with a light crop often produce unusually large nuts with comparatively thin shells. The value of a variety, therefore, depends largely upon its behavior after the trees reach full maturity and bearing.

Varieties Recommended.—The best marketable nuts are, as has been suggested, few in number, and most of these do well in all of the principal almond districts of California. Where the climatic and soil conditions are favorable there is no great difference in the behavior of the several varieties, but where these conditions are not so favorable certain varieties do better than others.

The Nonpareil (fig. 14), the best variety known at the present time for California conditions, bears more nearly uniform crops from year to year and shows a wider range of adaptation than any of the

Fig. 15.—Typical Drake almond tree in University Farm orchard; nine years old.

other good commercial varieties. It has proved itself to be satisfactory in every almond district in the state. The Drake (fig. 15) closely approaches the Nonpareil in this respect. The I. X. L. (fig. 16) and Ne Plus Ultra (fig. 17) are the most variable in their behavior. The blossoms of these two varieties seem to be more tender and hence more liable to injury under unfavorable conditions; gumming is more prevalent near the coast, and during harvest the slower ripening and opening of the hulls in the more moist atmosphere in many of the coast valleys cause excessive darkening and sometimes molding of the shell. The Ne Plus Ultra does best on comparatively high, well-drained soils, adjacent to the larger streams in the Sacramento valley, such as the lands along the Sacramento River, Putah Creek, Cache Creek, etc. It grows and produces well in the Banning district and in many of

the foothill sections where conditions are favorable. The I. X. L. does best on the foothills surrounding the Sacramento Valley, particularly on the west side. Varieties which ripen later than the Drake should be avoided in the Banning district and other sections of similar climatic conditions because of the liability to damage from the frequent October rains.

Fig. 16.—Typical I. X. L. almond tree in University Farm orchard; nine years old.

Doubtful and Undesirable Varieties.—There are a number of different varieties, such as the Eureka and Jordan which give promise of filling a limited place in the markets, but which have not yet been thoroughly tested throughout the state. It is still a question as to whether growing them in very large quantities would affect the price. The Jordan nut is of excellent quality, but in California the trees are variable in vigor. In some cases the trees make unusually

large, vigorous growth, while in others they are small and apparently stunted. In general, the Jordans do not bear sufficiently heavy crops to make them pay at the prevailing low prices.

Fig. 17.—Typical Ne Plus Ultra almond tree in University Farm orchard; nine years old.

Other varieties, such as the Texas, have been sufficiently tested to show their adaptability to most districts, but they are not recommended because of the difficulty experienced in marketing them at a profit in large quantities. The Texas has been planted extensively

in California without sufficient justification. It was planted because of its value as a pollinizer, and of its precocious and prolific bearing. In small quantities it was sold in less exacting markets as a Drake, but in larger quantities the trade has objected to it. Its lateness in ripening is making it harder each year satisfactorily to market the rapidly increasing tonnage of this variety. It should, therefore, be avoided in new plantings.

Unshelled Almonds.—Athough future markets will no doubt use shelled almonds very largely, there will always be a limited demand for unshelled almonds for use in the holiday trade and for home table use. Unshelled almonds for such purposes must be large, attractive nuts with light-colored, clean-looking shells, soft enough to be broken with the hands. The kernels must be well filled and free from gum. The I. X. L. is the most popular and highest priced nut for these purposes. The Ne Plus Ultra ranks next because of its attractive outside appearance and shape, one of the principal objections to it being its tendency to have gummy kernels. The Drake is another variety in demand by the holiday trade. It is moderately large, plump, and well filled with a good kernel and while not so attractive as the I. X. L. or Ne Plus Ultra, it is one of the most popular medium priced nuts. A certain class of trade prefers the Nonpareil, which appears to be growing in popularity because of the attractive kernel and the ease with which it may be shelled by hand.

Shelled Almonds.—The confectioners, on the other hand, care nothing for the shell. They want a medium or large sized kernel, uniform in shape, and plump; one that can be coated smoothly or evenly with candy. For blanching and salting purposes, the kernels must be large and smooth. The best California variety for this purpose is the Nonpareil. It is also the best nut for table use when sold unshelled. As a rule, the papershell varieties are the best for shelling because of the large percentage of unbroken kernels which may be obtained. The broken kernels and those obtained from cheaper and less desirable varieties are used largely by the bakers and almond-paste manufacturers.

Owing to the increasing consumption of shelled almonds and the probability of a still greater increase in the future, growers should arrange future plantings with a view to supplying the best shelling varieties. At the present time, the best shelling varieties are not ordinarily the heaviest producers. With a limited production they may not even bring as large returns as the poorer but heavier yielding varieties. As the production increases, which it is doing very

rapidly, the relative value of the best shelling varieties will increase in proportion and bring good prices when it will be impossible to move at a profit a heavy tonnage of a poor variety.

Size of Almonds—Per Cent of Kernels and Per Cent of Doubles.—Records of fourteen varieties of almonds grown in the same orchard under similar conditions of soil and culture have been kept at the University Farm at Davis, for the years 1913 to 1916 inclusive. These trees are all of the same age, except the Texas, Peerless, and Harriott, which are one year younger than the others. The figures in table 6 show that there is a wide variation among varieties, as regards not only the size, but the proportion of shell to the whole nut, and the proportion of double kernels.

TABLE 6

SHOWING NUMBER PER POUND, PER CENT OF KERNELS, AND PROPORTION OF DOUBLE KERNELS

Variety	Number of nuts per pound	Weight per cent of kernels to whole nuts	Number per cent of double kernels
Nonpareil	236	66.6	3.05
I. X. L.	152	52.28	.60
Ne Plus Ultra	167	56.45	7.37
Drake	145.5	44.48	8.54
Languedoc	211	49.16	.97
Texas	173	43.89	10.29
Reams	140.5	45.27	9.51
Lewelling	150	46.96	29.50
Peerless	124	36.05	6.62
Princess	238	70.6	1.88
California	216	70.43	.032
King	241	71.2	1.14
Harriott	167	53.68	.88
Jordan	74	25.23	2.93

The above figures are for hand-shelled almonds from young trees. It must be remembered that the figures will vary on older trees and also that the percentage of kernel to whole nuts will be lower for samples from commercial shelling plants.

Methods of Classification.—Almonds are classified according to hardness of shell:

Papershell.—Those having a thin, papery shell which may be broken easily between the fingers of one hand.

Softshell.—Those which have a more or less spongy or thin shell which may be broken between the fingers of two hands.

Standardshell.—Those requiring very strong pressure of the hand or the use of a nut-cracker to break. These may have a spongy or smooth outer shell.

Hardshell.—Those which cannot be broken by hand but require a sharp blow with a hammer or strong pressure with a nut-cracker to crack them.

The papershell varieties are excellent for shelling, as they contain a large percentage of kernels which may easily be obtained whole.

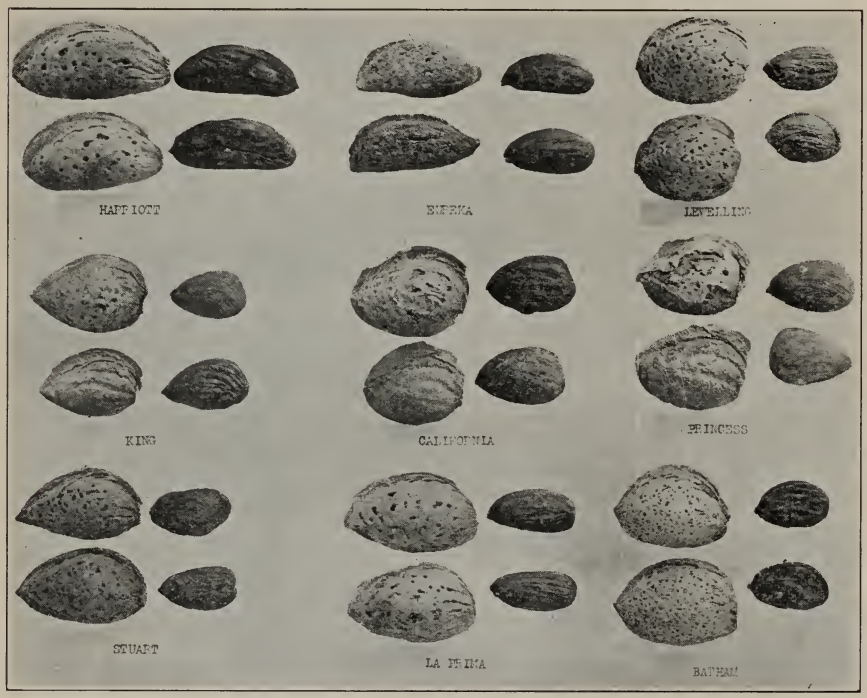

Fig. 18.—Almond varieties.

The principal objections are that birds are particularly fond of them since they can crack them easily, and that the shells are often poorly sealed. The latter fact makes it difficult to prevent worm infestation and the entrance of sulphur fumes into the kernel during the bleaching process. As a result, practically none of the papershells are bleached but are sold for shelling purposes.

The softshells are generally more attractive for table use because the shells are more perfect and, in commercial varieties, are brighter in color and more attractive. The shells are usually well sealed and can be bleached to give additional brightness with less danger of the fumes penetrating to the kernel than in the case of the papershells.

The standardshells have the greatest range in character, thickness, and hardness of shell. The percentage of kernel is too low to make them very attractive to the retail trade. Of this class the Drake is probably the best of the California varieties. Almond varieties of all these classes are shown in figures 18 and 19. These illustrations show most of the varieties grown to any extent in California and others that have attracted much interest and inquiry, together with the European Tarragona.

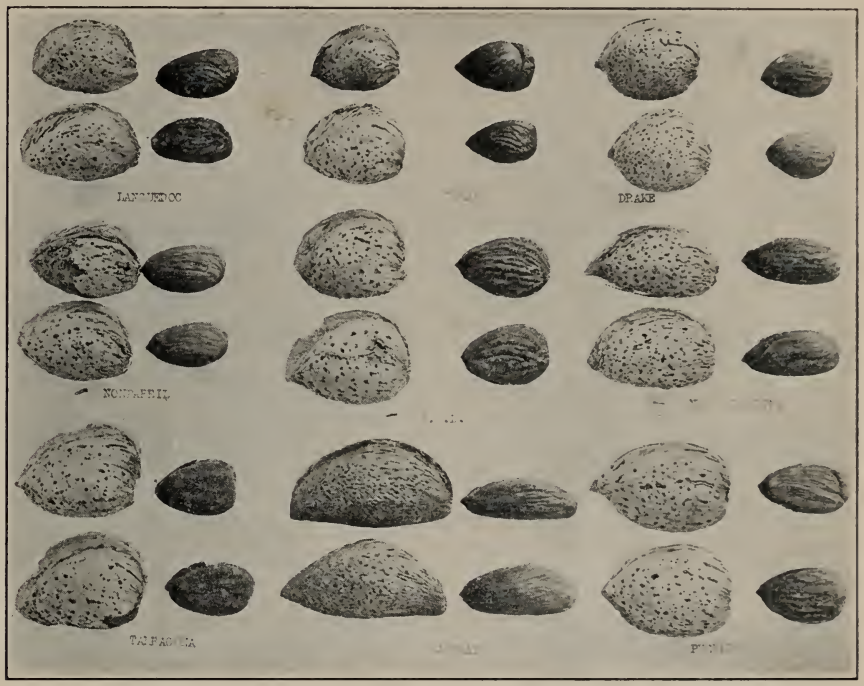

Fig. 19.—Almond varieties.

ACKNOWLEDGMENTS

The writers desire to express their appreciation to the California Almond Growers' Exchange, and to Mr. M. N. Wood, Pomologist, U. S. Department of Agriculture, who have provided certain data and given helpful suggestions, and to acknowledge the help and suggestions received from Dr. W. L. Howard, who gave valuable assistance in the preparation of the manuscript.

STATION PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION

BULLETINS

No.

253. Irrigation and Soil Conditions in the Sierra Nevada Foothills, California.
261. Melaxuma of the Walnut, "Juglans regia."
262. Citrus Diseases of Florida and Cuba Compared with Those of California.
263. Size Grades for Ripe Olives.
268. Growing and Grafting Olive Seedlings.
273. Preliminary Report on Kearney Vineyard Experimental Drain.
275. The Cultivation of Belladonna in California.
276. The Pomegranate.
277. Sudan Grass
278. Grain Sorghums.
279. Irrigation of Rice in California.
280. Irrigation of Alfalfa in the Sacramento Valley.
283. The Olive Insects of California.
285. The Milk Goat in California.
286. Commercial Fertilizers.
294. Bean Culture in California.
304. A Study of the Effects of Freezes on Citrus in California.
310. Plum Pollination.
312. Marlout Barley.
313. Pruning Young Deciduous Fruit Trees.
319. Caprifigs and Caprification.
324. Storage of Perishable Fruit at Freezing Temperatures.
325. Rice Irrigation Measurements and Experiments in Sacramento Valley, 1914–1919.
328. Prune Growing in California.
331. Phylloxera-Resistant Stocks.
334. Preliminary Volume Tables for Second-Growth Redwood.
335. Cocoanut Meal as a Feed for Dairy Cows and Other Livestock.
339. The Relative Cost of Making Logs from Small and Large Timber.
340. Control of the Pocket Gopher in California.
343. Cheese Pests and Their Control.
344. Cold Storage as an Aid to the Marketing of Plums.
346. Almond Pollination.
347. The Control of Red Spiders in Deciduous Orchards.
348. Pruning Young Olive Trees.
349. A Study of Sidedraft and Tractor Hitches.
350. Agriculture in Cut-over Redwood Lands.

No.

352. Further Experiments in Plum Pollination.
353. Bovine Infectious Abortion.
354. Results of Rice Experiments in 1922.
357. A Self-mixing Dusting Machine for Applying Dry Insecticides and Fungicides.
358. Black Measles, Water Berries, and Related Vine Troubles.
359. Fruit Beverage Investigations.
361. Preliminary Yield Tables for Second Growth Redwood.
362. Dust and the Tractor Engine.
363. The Pruning of Citrus Trees in California.
364. Fungicidal Dusts for the Control of Bunt.
366. Turkish Tobacco Culture, Curing and Marketing.
367. Methods of Harvesting and Irrigation in Relation to Mouldy Walnuts.
368. Bacterial Decomposition of Olives during Pickling.
369. Comparison of Woods for Butter Boxes.
370. Browning of Yellow Newtown Apples.
371. The Relative Cost of Yarding Small and Large Timber.
372. The Cost of Producing Market Milk and Butterfat on 246 California Dairies.
374. A Survey of Orchard Practices in the Citrus Industry of Southern California.
375. Results of Rice Experiments at Cortena, 1923.
376. Sun-Drying and Dehydration of Walnuts.
377. The Cold Storage of Pears.
379. Walnut Culture in California.
380. Growth of Eucalyptus in California Plantations.
381. Growing and Handling Asparagus Crowns.
382. Pumping for Drainage in the San Joaquin Valley, California.
383. Monilia Blossom Blight (Brown Rot) of Apricot.
384. A Study of the Relative Values of Certain Succulent Feeds and Alfalfa Meal as Sourses of Vitamin A for Poultry.
385. Pollination of the Sweet Cherry.
386. Pruning Bearing Deciduous Fruit Trees.

CIRCULARS

No.

87. Alfalfa.
113. Correspondence Courses in Agriculture.
117. The Selection and Cost of a Small Pumping Plant.
127. House Fumigation.
129. The Control of Citrus Insects.
136. *Melilotus indica* as a Green-Manure Crop for California.
144. Oidium or Powdery Mildew of the Vine.
151. Feeding and Management of Hogs.
152. Some Observations on the Bulk Handling of Grain in California.
154. Irrigation Practice in Growing Small Fruit in California.

No.

155. Bovine Tuberculosis.
157. Control of the Pear Scab.
160. Lettuce Growing in California.
161. Potatoes in California.
164. Small Fruit Culture in California.
165. Fundamentals of Sugar Beet Culture under California Conditions.
166. The County Farm Bureau.
167. Feeding Stuffs of Minor Importance.
170. Fertilizing California Soils for the 1918 Crop.
173. The Construction of the Wood-Hoop Silo.
178. The Packing of Apples in California.

CIRCULARS—(*Continued*)

No.

179. Factors of Importance in Producing Milk of Low Bacterial Count.
184. A Flock of Sheep on the Farm.
190. Agriculture Clubs in California.
199. Onion Growing in California.
202. County Organizations for Rural Fire Control.
203. Peat as a Manure Substitute.
208. Summary of the Annual Reports of the Farm Advisors of California.
209. The Function of the Farm Bureau.
210. Suggestions to the Settler in California.
212. Salvaging Rain-Damaged Prunes.
214. Seed Treatment for the Prevention of Cereal Smuts.
215. Feeding Dairy Cows in California.
217. Methods for Marketing Vegetables in California.
220. Unfermented Fruit Juices.
228. Vineyard Irrigation in Arid Climates.
231. The Home Vineyard.
232. Harvesting and Handling California Cherries for Eastern Shipment.
233. Artificial Incubation.
234. Winter Injury to Young Walnut Trees during 1921–22.
235. Soil Analysis and Soil and Plant Interrelations.
236. The Common Hawks and Owls of California from the Standpoint of the Rancher.
237. Directions for the Tanning and Dress- of Furs.
238. The Apricot in California.
239. Harvesting and Handling Apricots and Plums for Eastern Shipment.
240. Harvesting and Handling Pears for Eastern Shipment.
241. Harvesting and Handling Peaches for Eastern Shipment.
243. Marmalade Juice and Jelly Juice from Citrus Fruits.
244. Central Wire Bracing for Fruit Trees.
245. Vine Pruning Systems.
247. Colonization and Rural Development.
248. Some Common Errors in Vine Pruning and Their Remedies.
249. Replacing Missing Vines.
250. Measurement of Irrigation Water on the Farm.

No.

251. Recommendations Concerning the Common Diseases and Parasites of Poultry in California.
252. Supports for Vines.
253. Vineyard Plans.
254. The Use of Artificial Light to Increase Winter Egg Production.
255. Leguminous Plants as Organic Fertilizer in California Agriculture.
256. The Control of Wild Morning Glory.
257. The Small-Seeded Horse Bean.
258. Thinning Deciduous Fruits.
259. Pear By-products.
260. A Selected List of References Relating to Irrigation in California.
261. Sewing Grain Sacks.
262. Cabbage Growing in California.
263. Tomato Production in California.
264. Preliminary Essentials to Bovine Tuberculosis Control.
265. Plant Disease and Pest Control.
266. Analyzing the Citrus Orchard by Means of Simple Tree Records.
267. The Tendency of Tractors to Rise in Front; Causes and Remedies.
268. Inexpensive Lavor-saving Poultry Appliances.
269. An Orchard Brush Burner.
270. A Farm Septic Tank.
271. Brooding Chicks Artificially.
272. California Farm Tenancy and Methods of Leasing.
273. Saving the Gophered Citrus Tree.
275. Marketable California Decorative Greens.
276. Home Canning.
277. Head, Cane, and Cordon Pruning of Vines.
278. Olive Pickling in Mediterranean Countries.
279. The Preparation and Refining of Olive Oil in Southern Europe.
281. The Results of a Survey to Determine the Cost of Producing Beef in California.
282. Prevention of Insect Attack on Stored Grain.

The publications listed above may be had by addressing

College of Agriculture,
University of California,
Berkeley, California.

15*m*-4,'25